# Research Exposé:

# Does price affect critical mass? The creation of a widespread adoption car sharing system.

Submitted by:

Student: Matteo Saglia

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University of Trento - Department of Economics and Management
University Savoie Mont Blanc - IAE Savoie Mont Blanc
University of Kassel - School of Economics and Management
University of León - Faculty of Economics and Business Studies

## Abstract

Transportation is playing a key role in accelerating global warming and is the cause of many health issues. Many recent technologies are emerging to limit the negative effect of passenger cars on the environment and on society. One of these innovations, which is currently gaining importance, is car sharing. It is estimated that by 2026, there will be over sixty million car sharing users in the world (Statista, 2022). That said, studies suggest that car sharing, like other sustainable innovations, "would have the greatest impact on improving sustainability […] if it were offered nationwide" (Illgen & Höck, 2018, p. 1). However, the existing divergence among urban and rural areas makes a nationwide adoption of these technologies difficult. Smaller customer base, lower population density and longer distances travelled by providers and users, increases noticeably the costs of delivering services in rural areas (OECD, 2010). This creates a need by practitioners and policy makers to estimate the critical mass, but more importantly the necessary number of residents living in the area needed to achieve this critical mass. Such a framework was provided by Saglia, Wagner and Dion (2022). The researchers show that, if an area does not have enough residents to satisfy the critical mass requirements, the car sharing provider will fail (Evans & Schmalensee, 2010; Plavčan & Funta, 2020; Saglia, Wagner, & Dion, 2022). This research analyses how increases in price can potentially lower critical mass requirements, allowing car sharing services to be offered in rural areas and therefore stimulate national adoption, exponentially increase its environmental and social benefits. It also considers how policy makers may play a key role in doing so. Results show that … tbd

*Keywords: rural-urban gap, rural-urban divergence, critical mass, price level, car sharing, on-site services*

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## List of Abbreviations

| | |
|---|---|
| AES | Available Equivalent Services |
| APA | American Phycological Association |
| BCG | Boston Consulting Group |
| bcs | Bundesverband CarSharing |
| CAGR | Compound Annual Growth Rate |
| $C_F$ | Fixed Costs |
| CO2 | Carbon Dioxide |
| $C_V$ | Variable Costs |
| EU | European Union |
| EUS | Expected Use of Service |
| GHG | Greenhouse Gases |
| ICT | Information and Communications Technology |
| IPCC | Intergovernmental Panel on Climate Change |
| Kg | Kilogram |
| Km | Kilometre |
| Momo | More Options for energy efficient Mobility through Car Sharing |
| OECD | Organisation for Economic Co-operation and Development |
| P | Price |
| $S_P$ | Services Provided |

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# 1. Introduction

Although there is no exact answer that tells us what can be classified as a rural or urban area, most studies use population density as the single criterion necessary to distinguish the two (OECD, 1994). On the other hand, Pizzoli and Gong (2007) use a multidimensional approach that considers economic activities, geographic dimension, and population density to distinguish the two. Regardless of which definition is considered, it is of common knowledge that services, and especially on-site services, cannot always be offered equally in rural and urban areas due to their different population sizes and concentrations. It is often the case that some of these services are either not offered at all in rural areas or they are offered at higher prices or lower qualities. A representation of such divergence was presented by Zulauf and Wagner (2021, p. 1), according to whom "most sustainability innovations are adapted to the needs of urban areas. These innovations are either not offered at all in rural areas (e.g., car sharing) or require massive effort and restrictions to be usable or effective (e.g., ride sharing)." However, urban-rural divergence extends well outside the car sharing field. Such can be seen in the research by Safdar et al., (2022), who study the urban-rural gap in the academic competence; Whyte (2010) with regards to the existing gap in health care services; Byun, Irvin and Meece (2015), who analyse the rural–urban differences in college attendance patterns; Cutter, Ash and Emrich (2016), who researched the different conditions in disaster resilience between rural and urban regions; and Pong, DesMeules and Lagacé (2009), who conducted a cross-national study to analyse the divergence in health conditions between people living in urban and rural areas. These are just some of the many examples of studies analysing the urban-rural divergence. More detail will be provided in chapter two.

Researchers have also tried to analyse the reasons behind this divergence, and many suggest that it comes down to three main aspects: a smaller customer base, longer distances that need to be travelled by both users and providers, and lower population density (OECD, 2010). One characteristic that stands out and unites all three of these aspects is *critical mass*. According to the concept of critical mass, businesses need to reach a minimum number of customers or sales to achieve a certain goal, which is often covering all costs or profit (Evans & Schmalensee, 2010). For instance, according to researchers, "large numbers of regular users are required for a CS [car sharing] network to become profitable" (Illgen & Höck, 2018, p. 1), and if critical mass cannot be satisfied, businesses fail (Evans & Schmalensee, 2010). Generally speaking, if the willingness to use the service remains constant, areas with smaller population sizes, make it harder for businesses to reach their critical mass if they must offer their services on-site, while areas with bigger population sizes make it easier for the same businesses to reach their critical mass. “See, for instance, most of the platform-based services (e.g., car, bike or scooter sharing, delivery services based on predictive modelling) that require a minimum density of consumers, which is rarely found in rural areas” (Zulauf & Wagner, 2021, p. 2).This is also exemplified by the fact that multiple car sharing providers operate their fleets successfully in many cities around the world, while most rural areas have not yet been considered by car sharing providers, although studies suggest that “car sharing would have the greatest impact on improving sustainability if it were offered nationwide” (Illgen & Höck, 2018, p. 1).

What is even more important to know than critical mass, is how many residents must be living in an area in order to achieve this critical mass (Saglia, Wagner, & Dion, 2022). Having such value in mind would allow to answer the question: “if I were to start a car sharing business in this area, how likely would I be able to cover my costs?”

Saglia, Wagner and Dion (2022), used their model to demonstrate that, because car sharing providers could not reach their critical mass in most rural locations and therefore would not offer their service there, there is in fact an existing gap between rural and urban area. After having run their model, through which they were able to estimate the critical mass and the corresponding minimum required number of residents living in an areas, they were able to conclude that services available to rural residents are very limited compared to those offered to their urban counterparts, and this has to do mostly with the three variables described above. However, to the knowledge of the author, no research up until now has established how different price levels can change the number of residents needed to achieve critical mass. In other words, no research has been done to analyse how higher prices would allow service providers to also offer their services in rural areas. If, as hypothesized, higher prices are indeed needed for smaller residential areas to make a business financially viable, this would further prove the urban-rural divergence. Therefore, the aim of this research is twofold. This research wants to answer the questions:

1. How do price changes affect critical mass?
2. How do price changes affect the number of residents needed to achieve critical mass?

A second fundamental research gap that remains, is how policy makers can face this increase in price in rural areas, and what measures they can take in order to provide both rural and urban resident with equal services, guaranteeing similar qualities and similar prices. In other words, there is an academic gap that shows how policy makers may reduce the urban-rural divergence in the service sector. Therefore, this research tries to provide policy makers with more accurate information to help them implement the correct measures and take more transparent and rational decisions. This research also aims to provide fellow scholars with a more complete view of the model developed by Saglia, Wagner and Dion (2022), help address the field of car sharing services in rural areas, and create more interest towards the rural side of on-site services, as the rural side of car sharing has been excluded from most recent publications that address car sharing (Illgen & Höck, 2018).

The remainder of this paper is structured as follows: in the next chapter a more detailed elaboration of the theoretical framing will be provided, and in particular it will look into the transportation sector and it's negative effect on the environment and society, how car sharing may help alleviate these consequences and how this effect by car sharing is limited by the urban and rural divergence. A general overview on the research concerning the urban-rural divergence is also provided, together with a list of possible explanations and causes. Finally, the theory around the concepts of critical mass will be addressed and an analysis of how changes in prices can affect the critical mass will be presented. Then, in chapter three, a brief review of the relevant literature will be presented, to which follows section four with the research model. In this part, a detailed representation of how the model works and how the input data was retrieved will be proposed. Section five of the research will include the expected contributions to scholarity and the expected implications for society, policy makers and the business world. Chapter seven will conclude the research with a general summary of the study and will provide some concluding observations, while also inviting fellow scholar to further research the subject. The closing chapter will serve as a reference overview, which has been organised following the APA 7th generation standards and has been divided according to their provenience into bibliography and sitography.

## 2. Theoretical Framing

This chapter will include a detailed analysis regarding the scholarity discussion and theories about the topic and will explain the main concepts and notions needed to understand the research and its solutions. In order to be more clear, the theoretical framing will be divided into six sub-chapters according to the main topics of interest: transportation and it's environmental and social concerns, the role on carsharing and it's development, the existing urban-rural divergence that is affecting most areas, the concept of critical mass and how this may affect the urban and rural divide, and how prices may affect critical mass, and finally what instruments policy makers have to reduce the urban-rural gap.

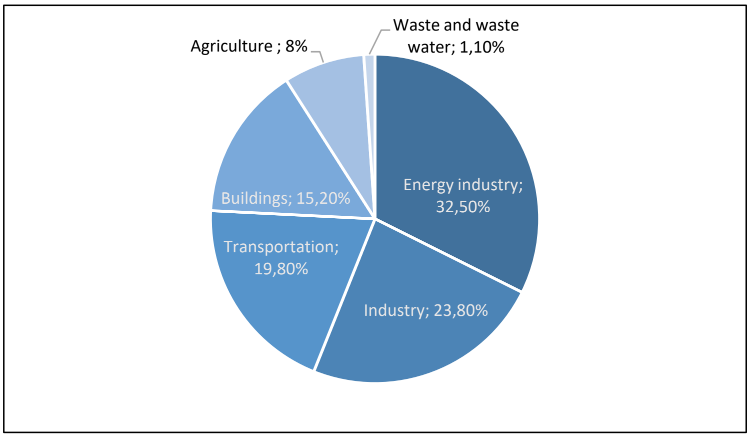
## 2.1. Contribution and Effect of Transportation on Emissions and Society

Transport is a major key player in the creation of greenhouse gas emissions, as well as producing many other types of negative externalities, such as noise, congestion, road injuries, and air pollutions. Globally, transport is responsible for the production of huge quantities of particle matters, carbon dioxide, and carbon monoxide (Katze, 2003; Migliore, D'Orso, & Caminiti, 2019; Rudolph & Thomas, 1988; Weeberb, 2018). The presence of these pollutants increasingly compromises the well-being of existing populations and perhaps, more importantly, the environment of generations still to come (Mulley, 2017). Some of the air pollution related diseases include asthma, lung cancer, dementia, high blood pressure, and premature deaths (Requia et al., 2018). "Ambient air pollution is the leading environmental health risk factor globally, resulting in nearly 3.5 million premature deaths in 2017" (Anenberg et al., 2019, para. 4). A study conducted by the *International Council of Clean Transportation* (ICCT) on February 2019, aligned with the *Global Burden of Disease Study 2017* (GBD 2017), discovered that emissions coming from transportation were a leading factor in the creation of air pollution through the production of tailpipe emissions, evaporative emissions, resuspension of road dust, and particles from brake and tire. According to their study, these emissions led to approximately 361.000 premature deaths worldwide in 2010 and 385,000 in 2015, which accounts to over 11% of mortality connected to air pollution. Following the introduction of innovative systems, such as electric vehicles and alternatives to private vehicle ownership (e.g., car sharing, ride sharing, carpooling, etc.) and based on the current adoption trends, it is expected that there could be a slight reduction in greenhouse gas emissions connected to transportation in the future. However, "unless the pace of transportation emission reductions is accelerated, these health impacts are likely to increase in the future as the population grows, ages, and becomes more urbanized. […] The majority of estimated transportation emissions-related health impacts occurred in the top global vehicle markets. In 2015, 84% of global transportation-attributable deaths occurred in

G20 countries, and 70% occurred in the four largest vehicle markets: China, India, the European Union (EU), and the United States" (Anenberg et al., 2019, para. 2). According to Statista (2022), transportations accounted to a staggering 19.4% of Germany's greenhouse gas emissions (see Figure 1), which many studies link directly to global warming (Al-mulali, 2012; Florides & Christodoulides, 2009; Liddle, 2012). Global warming alters the ecology and creates instability, leading to devastating results. Similar values can also be found for most other European countries.

**Figure 1**

*Distribution of greenhouse gas emissions in Germany in 2021, by sector*

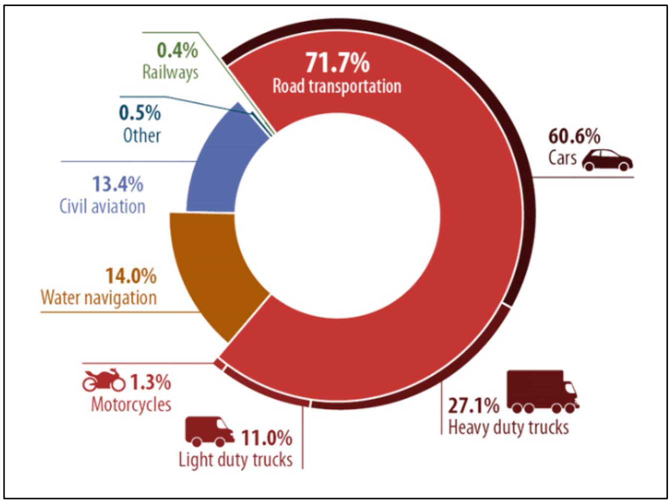



*Note. The figure represents how each major sector in Germany contributed in 2021 towards the creation of GHG. Its aim was to remark that transportation was the third biggest contributor, with 19.8%. The data was retrieved and elaborated on November 2022 from Statista (2020). Germany: GHG emissions by sector 2019.* *https://www.statista.com/statistics/989341/greenhouse-gas-emissions-by-sector-germany/*

Much research about pollution coming from transportation has also been conducted by the *European Parliament* (2022), following their goal of achieving a 90% reduction of transport greenhouse gas emissions by 2050 compared to 1990 levels. However, a study they conducted in 2022 with the *European Government Agency* discovered that transportation is the only sector where greenhouse gas emissions have increased in the EU in the past three decades, rising 33.5% between 1990 and 2019. Although many innovations are helping in reducing these values, current projections put the decrease in transport emissions by 2050 at only 22%, far behind their 90% ambition. According to the *IPCC Report* (2014), "public health impacts are projected to increase due to climate change and extreme weather events (e.g., storms, floods, and droughts), increasing number of wildfires, and variations in levels of air pollutants (both indoor and ambient air pollution)" (Requia et al., 2018). Currently (2019), road transportation accounts to almost 72% of transport emissions in the EU, with passenger cars being the biggest contributors holding 60.6% of the total transport emissions (see Figure 2). This value becomes even more important if during the calculation of the amount of CO2 produced by a car, not only the CO2 emitted during use is taken into consideration, but also the emissions caused by its production and disposal.

**Figure 2**

*Transport greenhouse gas emission in the EU by transport mode (2019)*




*Note. The figure divides among the several transportation sources, how much each source contributed in 2019 to the overall transportation production of greenhouse gas in the EU. The figure was retrieved on the November 2022 from European Parliament. (2019, April 18). CO2 emissions from cars: facts and figures (infographics)* [https://www.europarl.europa.eu/news/en/headlines/society/20190313STO31218/co2-emissions-from-cars-facts-and-figures-infographics](https://www.europarl.europa.eu/news/en/headlines/society/20190313STO31218/co2-emissions-from-cars-facts-and-figures-infographics)

In the report by the *European Parliament (2022, pp. 265-382)* it was stated that "at the moment average occupancy rate was only 1.6 people per car in Europe in 2018.

Increasing it by car sharing or shifting to public transport, cycling and walking, could help to reduce emissions." Therefore, using alternatives to private car usage, such as car sharing, could help reduce noticeably both emissions and other problems like traffic congestion and noise pollution. Up to now, measures aiming to diminish vehicle traffic and incentivise shifts towards using public transport and other non-polluting methods of travel, like walking or cycling have generated few positive effects (Ortar & Ryghaug, 2019, p. 1868), and more than one billion cars are present today in the world, with number expected to grow to two billion by 2030 (Sperling & Gordon, 2009).

### 2.2. Outlook on the Car Sharing Market

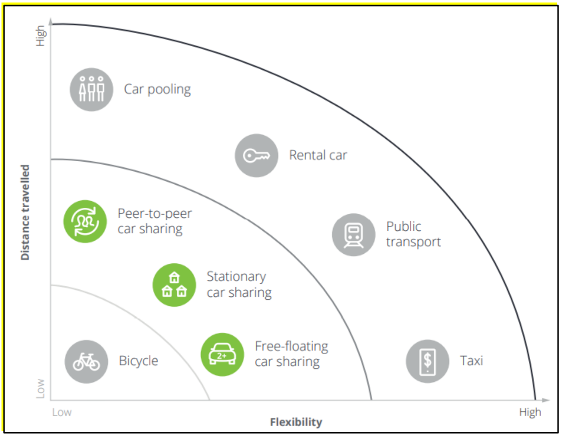
"The problems related to traffic emissions are becoming increasingly pressing and serious, especially in big cities where the private car plays the key role in the mobility of people, being excessively used, while walking, cycling and the use of public transport are often seen as secondary options and are hampered by a poorly urban environment. Therefore, solutions must be found to reduce the number of cars circulating in the city and to support the most sustainable modes of transport at the same time, to reduce emissions of greenhouse gases and harmful substances. A modal alternative which is of undoubted interest could be represented by carsharing" (Migliore, D'Orso, & Caminiti, 2020).

Car sharing can be defined as process of sharing vehicle services amongst members, thereby giving them access to a fleet of vehicles, which are usually owned by the car sharing providers (Loose, Mohr, & Nobis, 2006). According to this definition, the fleet of cars is used for multiple trips by several individuals throughout the day. Car sharing is also an example of a product as a service, according to which, consumers do not buy or own a product, but rather purchase the services through product provides (Best & Hasenheit, 2018). Car sharing differs from ride sharing or carpooling because it is not designed to transport a group of individuals to a common destination, but rather it acts as an alternative to private car ownership by providing people with convenient access to a shared fleet of vehicles (Katzev, 2003). In car sharing it is the user who drives the car, whereas in ride sharing or carpooling, it is someone else that drives the car for the user, who acts as a mere passenger. Car sharing also differs from car rentals, as users only pay for the duration of their trip, which may be even a few minutes long, whereas in car rental the user must usually pay at least for the whole day (Katzev, 2003). There are two main existing types of car sharing: station-based, also known as stationary car sharing (e.g., Greenwheels or EVCARD), and free-floating car sharing (e.g., Share Now, Sixt share, WeShare, Miles or Enjoy). “Station-based car sharing enable customers to pick up a car at a car sharing station and bring it back to either the same station or a different car sharing station [of the same provider]. Prices for station-based car sharing are usually calculated per hour, and cars can be booked several weeks in advance. When it comes to free-floating car sharing, cars can be found all over the service provider's business zone and parked throughout this zone after use, in accordance with the traffic regulations. Free-floating car sharing vehicles are booked via a smartphone app, and prices are usually calculated per minute” (Statista, 2022, para. 2). Car sharing is not a new concept; however, the development of Internet has allowed for a large-scale supply of the service (Lagadic, Verloes, & Louvet, 2019). According to a study conducted by Deloitte (2017), both fee-floating and stationary car sharing offer low/medium possibilities to travel long distances compared to other traditional transportation methods like public transport, car rentals and car pooling, although stationary car sharing allows for longer distances travelled. Also, both offer medium levels of flexibility, as they are more flexible than cycling and car pooling, but less flexible than taxies, public transport and partly also of car rental (see Figure 3). However, free-floating car sharing appears to be more flexible than stationary car sharing. Peer-to-peer car sharing is another existing type of car sharing in which private individuals share their own cars with other users, and cars are usually booked online through an intermediary (Statista, 2022). Peer-to-peer car sharing will not be considered for the scope of this research.

**Figure 3**

*Classification of car sharing amongst other existing mobility methods*

Kommentiert [SM1]: Is it clear enough? Should I cancel it or keep it? Or try and make my own?



*Note. This figure classifies existing transportation methods according to their flexibility and travel distance possibilities. According to this graph, free-floating car sharing allows for lower distances travelled and medium flexibility, while stationary car sharing offers lower flexibility, but higher possibilities of distance travelled. Retrieved in November 2022 from Deloitte. Car Sharing in Europe Business Models, National Variations and Upcoming Disruptions.* https://www2.deloitte.com/content/dam/Deloitte/de/Documents/consumer-industrial-products/CIP-Automotive-Car-Sharing-in-Europe.pdf

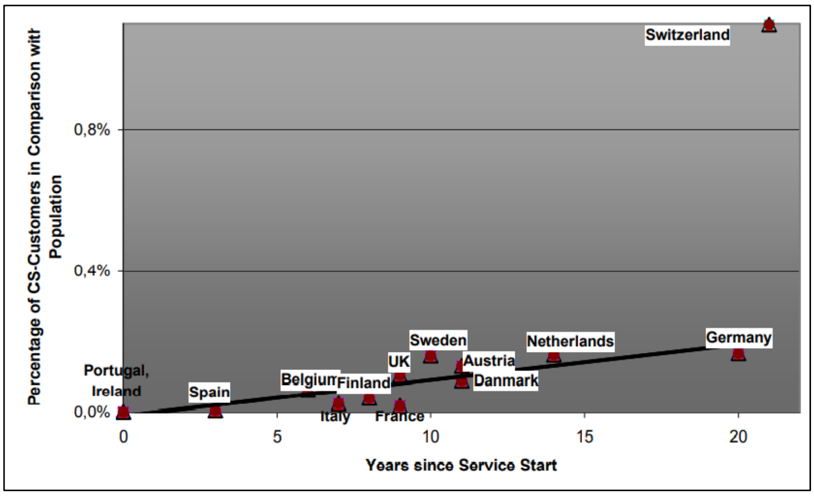
A periodic research conducted by the *Institution of Transportation at Berkeley University* regarding the car sharing market outlook, projected that on October 2018, car sharing was present in 47 nations across all continents (except Antarctica), it had roughly 32 million members sharing over 198,000 vehicles (Shaheen & Cohen, 2020), and it was growing at a yearly 24% compound annual growth rate (Zhang et al., 2018). From their data, it was also possible to notice that users had more than doubled in 2018 compared to 2016 levels, while vehicles increased by approximately 26% in the same period. According to the *BCG* (2016), car sharing services were used for roughly 2.5 billion minutes by users around the world in 2015, which brought car sharing providers over €650 million in revenues. It is important to notice that these values are representative of the 2015 situations, and as users more than doubled in 2018, and have continued to grow, use of the service and revenues will have followed similar trends. In fact, according to Statista (2022), car sharing revenues are expected to reach well over €10 billion by the end of 2022 and is predicted to arrive at €13.91 billion in revenues by 2026, thanks to the 60.5 million estimated worldwide users.

Asia is the largest carsharing region measured in terms of members, which accounted for 71.4% of worldwide membership, but also in terms of car sharing vehicles, with 54.4% of global fleets. The world's second largest carsharing market, is Europe, followed by North America. When looking in specific to the European market, two main areas stand out in terms of success, measured in car sharing users: Switzerland and Germany (Shaheen & Cohen, 2020). When assessing the German market, which is currently the biggest car sharing market in Europe (Best & Hasenheit, 2018; Deloitte, 2017), the *Bundesverband CarSharing* (the German national car sharing organisation), reported that as of the 1st of January 2022 there were 243 car sharing providers in the country, operating in 935 locations, and approximately 3.4 million registered members. However, it is empirically evident that only large cities in Germany with more than 100,000 inhabitants offer car sharing services and finding car sharing in smaller rural areas is very rare (Silberer et al., 2022). Also, car sharing accounts for only 0.1% of total kilometres driven by passenger vehicles (Best & Hasenheit, 2018).

The market is dominated by the four major providers: ShareNow, Miles, Sixt share and WeShare, which offer car sharing in a total of seven major cities and some surrounding municipalities. Out of the 3.4 million users, approximately 2,600,000 authorized drivers are registered with (at least) one free-floating provider. However, the success of these two countries may be related to the number of years car sharing has been present in the country. Research conducted in 2010 by Loose for European backed project *momo* (*More Options for energy efficient MObility through Car Sharing*) discovered a trend between the car sharing participation and the years since the service started as can be seen in Figure 4.

**Figure 4**

*Car sharing participation per country in relation to the years of service (2010)*




*Note.* *Figure 4 aims to demonstrate the connection between the years that a car sharing service has been running in a country and the percentage of car sharing customers (in comparison with the population). The aim is to show that the more years a country has had a car sharing service, the higher the adoption rate is within the country and in particular how this was true for Germany. The figure was retrieved in November 2022 from Loose, W. (2010). The state of European car sharing. Project Momo Final Report D, 2, 1-119.* [*http://www.car-sharing.info/images/stories/pdf_dateien/wp2_report__englisch_final_2.pdf*](http://www.car-sharing.info/images/stories/pdf_dateien/wp2_report__englisch_final_2.pdf)

## 2.3. The Environmental, Social and Economic Benefits of Car Sharing

As can be seen from Figure 4, the first car sharing provider was established in Switzerland back in 1987, most likely following the strong debates about the dying forests in the area at that time. It was seen as a way to limit the harmful pollution attacking and suffocating the trees (Katzev, 2003). Since then, many studies have been conducted regarding car sharing and its many environmental and social benefits, providing a broad understanding of the numerous reasons why car sharing can be considered as a more sustainable alternative to car ownership. One obvious benefit is represented by the decreased number of cars owned by households (Becker, Ciari, & Axhausen, 2017; Finkhorn & Müller, 2012; Le Vine & Polak, 2019; Martin & Shaheen, 2016). In fact, car sharing participants distinguish themselves for owning fewer cars than the population average (Clewlow, 2016; Loose, 2010). Car sharing is a new option which provides both flexibilities, like private car ownership, and affordability, like a public transport (Zhou & Kockelman, 2011). Back in 2003 it was considered that "if each car-share vehicle removes anywhere from five to six vehicles from the road, it could yield considerable savings in the resources required to manufacture, maintain, operate, and store the existing automotive fleet" (Katzev, 2003, p. 84). To the satisfaction of these researchers, a 2005 study conducted by Italian based *ICS* (Iniziativa Car Sharing, meaning Cars Sharing Initiative), the umbrella organization representing all car sharing in Italy, estimated that for every shared car that travels over 20.000 kilometres a year replaces at least 8 privately owned cars. An even more recent field study conducted in 2010 in the United Kingdom showed that for each car sharing vehicle approximately fourteen privately owned cars were replaced (Loose, 2010) and these values grow even more (approx. 25) when considering only the inner-city residential areas (Bundesverband CarSharing, 2012). The same research also shows that although most household that take part in car sharing services still own a personal car, the number of cars owned has dropped, meaning that many second or third cars are being disposed of. Additionally, the BCG (2016) estimated that in 2021 for every new vehicle sold to a car sharing provider (96,000), approximately three cars (278,000) private vehicle sales will be saved. The same research projected that in 2021 roughly 792,000 vehicles purchases will be avoided thanks to car sharing globally. "Assuming a car with an average lifespan, approximately one fifth of the emissions and climate damage it is responsible for are caused during the production process of the car – before a single kilometre is driven" (Loose, 2010, p. 79).

Less vehicles naturally correlates to a decrease in the production of CO2 and air pollution from petrol and gas consumption and from the car manufacturing process and disposal. Rabbitt and Gosh (2016) considered that the introduction of the carsharing service in Ireland would effectively reduce CO2 emissions due to the reduction of car ownership by carsharing users (Migliore, D'Orso, & Caminiti, 2020). Chen and Kockelman (2016) even committed to disclose that by analysing the whole car sharing life-cycle (which includes also vehicle manufacture and fuel production), individuals transport-related greenhouse gas emissions may reduce by 51% after a person joins a carsharing service, which according to the US Department of Transportation accounts approximately to 11-16% of the average American household's transport-related greenhouse gas emissions per year (USDOT, 2009). According to a 2016 study by *bcs* (Bundesverband CarSharing), 78 percent of customers of station-based car sharing providers in city centres no longer have their own car. If we enlarge these results to the entire population, Martin and Shaheen (2016), when studying the patterns of Car2Go users, register a 10% reduction in the number of cars owned by car sharing users. Giesel and Nobis (2016), on the other hand distinguish different patterns of car ownership based on the type of car sharing. According to their research, which was conducted in Germany, car sharing leads to a reduction of private car ownership of 7% when using free-floating car sharing, like DriveNow, and 15% when using station-based car sharing services, such as Flinkster. Additionally, not only do they own less cars, but empirical evidence also indicates that people in Europe who use car sharing drive considerably less than when they owned a car (Cervero, Golub, & Nee, 2007; Martin and Shaheen, 2016; Munheim, 1998; Steininger, Vogl, & Zettl, 1996) and make far less trips (Zhou & Kockelman, 2011), with frequency of car use dropping by more than one third. According to Best and Hasenheit (2018), for every kilometre driven with a car sharing vehicle, 4.7 kilometres where not driven with privately owned cars. Also, the cars that are use through car sharing produce up to 15 to 20 percent lower CO2 emissions compared to the national average, which in some cases can be even up to 25 percent lower (Loose, 2010; Katzev, 2003). According to Martin and Shaheen (2011b), who studied the use of car sharing in North America, registered a staggering annual reduction of 34% of CO2 by those using these services. This higher value could be tied to the fact that, overall, US drivers tend to use bigger and more polluting cars than their European counterparts. Whether it is 25% or 35% in CO2 reduction, this is the result of two main aspects: car sharing vehicles are on average more modern than the rest of the passenger car fleet and they are smaller and more energy-efficient than the rest of the passenger car fleet. These values could increase further considering that car combustion engines are particularly pollutant when the engine is cold. However, car sharing generally has multiple users a day for the same car, with change-up times (time that passes from one rental to the next) that tend to be on average around half an hour. This allows the car engine to maintain a constant warmer temperature throughout the day and avoid the highly polluting uses when engines are cold (Bebkiewicz et al., 2021).

Additional support could come from the individual's higher cost awareness thanks to more transparent car sharing pricing. Because payment for using the service is a variable cost that is based on the duration and the number of trips, people are more likely to travel less and for less time by car in order to spend less, avoiding unnecessary distances driven and trips. In the case of privately owned vehicles, on the other hand, car costs mostly come from fixed costs of owning the car and there is no direct disbursement of money based on the length of the trip, so people would likely use the car more often and for longer times (Katzev, 2003). This leads to the attitude of: "the car is paid for anyway so we should use it as much as possible" (Loose, 2010, p. 81). As people become more aware of the cost of driving cars, they also tend to act more rationally with their daily mobility decisions (Cervero, Golub, & Nee, 2007; Coll, Vandersmissen, & Thériault, 2014; Huwer, 2004; Nobis, 2006; Zheng et al., 2009).

Many car sharing providers have also started adding electric vehicles to their fleets and some have even converted their entire fleet to electric vehicles. This could lower emissions exponentially, especially if these providers use energy coming from renewable sources, but even if this energy is coming from the grid say Choma et al. (2020), Shaheen and Cohen (2012), and Zhang et al. (2018). According to these researchers by cutting tailpipe emissions, electric vehicles have the possibility to reduce the production of both GHGs and other pollutants, like particulate matter (Choma et al., 2020). Research by Baptista et al. (2016), estimated that the adoption of hybrid (vehicles working with both electric and combustion engines) and electric vehicles, could reduce emissions by a further 35% to 65% if adopted by car sharing services in Portugal. For instance, German car sharing provider, *WeShare*, operate in Berlin and Hamburg with an entirely electric car fleet that is powered completely by green electricity and still manage to offer competitive prices.[1] This is not the only example.

A study conducted by Loose (2010, p. 5) in Switzerland on the emission produced by car sharing users and car owners, concluded that each active Swiss car sharing user emits 290

[1] https://www.we-share.io/ viewed on the 02.11.2022

kg of $CO_2$ less each year than he or she would without car sharing. According to these results, the researcher consider that car sharing has a great, but also unexploited potential to drastically reduce European air pollution and that by allowing car sharing to operate as a market-based service, transport can be planned more rationally and more resource-efficiently. Similarly, Nijland and van Meerkerk (2017), argue that Dutch car sharing members emit between 240 and 390 kilograms less per person per year due to the reduction of owned vehicles and the use of cars (Migliore, D'Orso, & Caminiti, 2020), while Finkhorn and Muller (2011) estimated a reduction between 146 and 312 kg of $CO_2$ per member per year in the Germany city of Ulm. To further solidify these results, a study by Matin and Shaheen (2011) estimated that the full impact of adopting car sharing could reduce a households greenhouse gas emissions by 0.84 tons a year. Another study conducted in 2007, by the UK Energy Research Centre projected that a car sharing support programme could save up to 64,000 tonnes of $CO_2$ annually based on 88,000 potential users and 115,000 tonnes of $CO_2$ annually with 118,000 users (UK ERC 2007). Since then, users have increased exponentially, and as mentioned in the beginning of this chapter, approximately 32 million car sharing members are active today. Martin and Shaheen (2010), found that 46% of carsharing users in North America who owned a private car, drove on average 21,250 km a year before joining the service. This value reduces noticeably after becoming a car sharing member and reached a mere 800 km per year. The researchers also say that the same users have since sold their car and have not bought a new one to replace it.

It is also estimated that car sharing customers are more likely to use public transport, cycle and walk instead of taking the car, compared to the general population (Best & Hasenheit, 2018; Bundesverband CarSharing, 2016; Martin and Shaheen, 2011b; Migliore, D'Orso, & Caminiti, 2020; Kopp, Gerike, & Axhausen, 2015; Zoepf & Keith, 2016). Once a household becomes an active user of car sharing services, they tend to replace passenger car riding with other more sustainable alternatives. For instance, 19 percent use buses and trains more often, while 14 percent of people tend to use bikes more often (Bundesverband CarSharing, 2022). Car sharing is usually not the preferred mode of transport by car sharing user when other modes, such as public transport, bike and walking, are available. Whereas, car owners tend to favour car transport to any other means of transport (Loose, 2010), due to its availability flexibility and comfort. Also, they begin to combine rides more often and start commute more with friends and other acquaintances, ultimately rising the occupancy rate of passenger cars. However, it's also important to consider the possibility that car sharing, and especially free-floating car sharing may lead to people switching from using public transport to using car sharing instead (Becker, Ciari, & Axhausen, 2018; Firnkorn and Müller, 2012; Papu Carrone et al., 2020), which would reduce some of the benefits of car sharing. However, according to Ceccato, Chicco, & Diana (2021, p. 1), "the substitution rate of private cars is, on average, almost five times that of public transport", meaning that, although some car sharing users have adopted the service as an alternative to public transport, more than five times as many people have adopted car sharing as an alternative to private car ownership. Also, research conducted by Lane (2005) in the Philadelphia area discovered that, among users that owned fewer cars after becoming a member with the car sharing provider, 37% tended to use more public transport compared to prior levels, but 12% reduced their public transport usage in exchange for car sharing. The reason behind these results, could be a possible substitution or complementarity effect between car sharing services and public transport (Ceccato & Diana, 2018; Coll, Vandersmissen, & Thériault, 2014, Kopp, Gerike, & Axhausen, 2015). Free-floating car sharing appears to be more likely to substitute public transport due to its flexibility (Becker, Ciari, & Axhausen, 2017), while stationary car sharing is more likely to compliment public transport, as it is used mostly for day trips rather than short commutes in the area. When analysing also other transport modes, evidence shows that car sharing acts as a substitute for private car rides, cycling and walking, and acts as a complementary mode to bike sharing and taxis (Ceccato & Diana, 2018).

Additionally, car sharing may act as a mechanism for trialling innovative and less harmful technologies, like electric vehicles or hybrid-vehicles (Zoepf & Keith, 2016). For instance, Zoepf and Keith (2016) discovered that out of the 709.000 users of Zipcar car sharing services present in 2013 in the United States if America and Canada, approximately half (50.5%) drove a hybrid vehicle for the first time through the car sharing service. This introduction to innovative technologies may lead people to then switch towards them in the future, however its effects on future adoption rates are still uncertain. The researchers also showed that, on average, a car sharing user perceives to gain more utility when using the service, if he or she is driving a hybrid vehicle.

Car sharing does not necessarily have to be seen only as good for the environment, because it can also benefit people in the economic and social sense. In fact, "for those cars who drive fewer than 10,000 to 12,000 kilometres annually and who do not drive a car daily, car sharing represent a more cost-effective service in comparison to car ownership" (Best & Hasenheit, 2018; Loose, 2010, pp. 7-8). This is especially true for electric vehicles. Although electric vehicles could have many benefits on the environment, they have not reached the extent of their full potential, mainly due to their higher cost compared to a combustion engine vehicle. Therefore, according to Wappelhorst et al. (2014), a shared structure of vehicle ownership allows to spread the cost among many users and increase the adoption of electric vehicles. Also, even though the study relates back to the 1990s and values may not be totally representative of the current situation, Gordon, Richardson, and Jun (1991, pp. 416-420) provide a clear idea of how a reduced number of vehicles in urban settings may help by reducing traffic congestion, by stating that "traffic congestion is an increasingly serious problem in many cities. Traffic is estimated to cost the United States 1.2 billion hours of lost time and 2.2 billion gallons of gasoline each year, not to mention a $30 billion annual loss in productivity alone" (Katzev, 2003, p. 2). A similar study conducted by Kim in 2019 using the bottleneck model, came to a similar result: because of individuals queuing time on the streets the annual cost of congestion suffered by US drivers is approx. $29 billion a year (Kim, 2019). This however does not regard only the USA but can be extended to most cities around the world. According to Kahn (2013), Dhaka, the capital of Bangladesh, around 3.9 billion US dollars each year to traffic congestion and Mao, Zhu, and Duan (2012) estimated that Beijing lost approximately 58 billion Yuan (≈ $8 billion). Traffic congestion, however, does not only mean lost money, but it is also a potential cause of road casualties and accidents. It is in fact empirically proven, that many car accidents happen due to congestion (Change et al., 2022; Green, Haywood, & Navarro, 2016). However, set aside the congestion issue, car sharing providers also offer new job opportunities, access to passenger cars for people who would otherwise have limited transportation resources (e.g., cycling or walking infostructure could be missing or potentially dangerous for the user if done on the roads) and leads to a decrease in pressure on parking, reducing the excessive, and quite often incorrect, occupation of public land by cars. "The problem of vehicle parking is increasingly present in cities and often people have to spend a lot of time looking for a free parking space, causing a significant increase in fuel consumption and emissions that are added to those due to traffic" (Migliore, D'Orso, & Caminiti, 2020, p. 2128). Studies conducted in 22 U.S. states show that drivers looking for parking are responsible for approximately 30% of traffic congestion in cities (Shoup, 2021). These are problems that can be alleviated through car sharing, especially considering that on average cars are used less than two hours per day, but still occupy a parking space the rest of the time (Waserhole & Jost, 2016). These are just some of the issues that make cities unlivable (European Commission, 2017). Nonetheless, all issues related to mobility and traffic in urban areas are becoming a main concern in many policies intended to improve the quality of life (Migliore, D'Orso, & Caminiti, 2020)and car sharing has the potential to "improve air quality and to free up public space for cycling lanes, public transport, pedestrian areas and amenities" (Lagadic, Verloes, & Louvet, 2019).

Additionally, car sharing generates a sense of belonging to a community in which members share active and sustainable lifestyles (Migliore, D'Orso, & Caminiti, 2020), which helps reduce stress and anxiety. It can help lessen the spread of diseases related to physical inactivity, such as obesity, by reducing the excessive use of cars and it can in the social sense, by allowing household that do not have the chance of owning a private car, to have access to one, without enduring the burden of buying one (Wappelhorst et al., 2014). Finally, the OECD (2010) estimated that there is a high growth potential in employment in rural services in fields such as, health care, tourism, and various environmental services. Car sharing could thus help boost rural employment and the overall economic situation of the region. In fact, car sharing has grown to be a €12 billion industry as of 2022 (Statista, 2022).

### 2.4. Urban-Rural Divergence

Although it is possible to see that the adoption of a well-structured car sharing service could bring many benefits to the area in which it operates, the widespread acceptance of car sharing services, which would allow to exponentially increase its environmental, economic and social benefits, faces a critical issue. Car sharing, like many other services, are not currently offered equally in every area but are rather focused in urban locations where most of the population resides in high density areas and where multiplier effects are usually larger (OECD, 2010; Prieto et al., 2017). "Carsharing is a niche product and has been proven viable only in a limited range of urban settings" (Celsor & Millard-Ball, 2007, p. 68). Research on car sharing customer patterns found that the most frequent users are young males living in denser urban areas (Clewlow & Mishra 2017; Kopp, Gerike, & Axhausen, 2015), while analysis on the electric vehicle market found that "residents living in a rural area seem to be as open towards e-carsharing as people living in an urban context. However, this group alone cannot contribute to the full economic viability of the system" (Wappelhorst et al., 2014, p. 374). Additionally, when looking at the Deloitte Report (2017, p. 5) that discusses the situation of car sharing in Europe, phrase such as: "free-floating providers operate only in big cities" like Stockholm, Copenhagen and Oslo, "Milan is the centre for free-floating, with 80% of the market" and the rest is covered by Rome, Florence and Turin, "[in France car sharing can be found] mostly in big cities" like Pairs, Lyon and Bordeaux, and "London is UK's centre for car sharing", provide a clear idea of how car sharing is currently based mostly, if not only, around the urban context. Even in the literature, this divergence can be seen. "Research and practical experience generally concentrate on urban contexts where the positive outcomes of carsharing and e-carsharing have been evaluated intensively. However, less attention has been paid to the comparison and potential of carsharing in rural areas facing different transport problems such as inadequate public transportation" (Wappelhorst et al., 2014, p. 375). Nevertheless, the development of car sharing in rural areas remains an important challenge (Lagadic, Verloes, & Louvet, 2019).

There is currently no universally accepted definition of *urban* or *rural* area (European Commission, 2016; OECD, 2010; Our World In Data, 2019; The World Bank, 2020; United Nations, 2019). Many studies use population density as the single criterion necessary to distinguish the two (OECD, 1994), and many others use minimum population threshold in a settlement (Our World In Data, 2019). Pizzoli and Gong (2007), tried to develop a more sophisticated method which uses a multidimensional approach that considers economic activities, geographic dimension, and population density to distinguish the two areas. Other studies use administrative decisions, sectorial employment, or existing infrastructure to establish what can be considered as an urban area. For this reason, results among different studies vary a lot depending on what criteria was used and what threshold was employed, making comparisons exceedingly difficult. For instance, although both use the minimum population threshold in a settlement criterion, the Swedish and Danish governments set the threshold for defining urban areas at only 200 inhabitants while the Japanese government sets it at 50,000. Obviously, these two vastly different values lead to very varied results.

The European Commission used to adopt each countries personal definition of urban and rural area, however, due to the diverging instruments used they believed a new harmonised indicator across all countries was necessary to allow easier comparisons. For this reason, together with the ILO, FAO, OECD, World Bank and United Nations, the European Commission (2020) developed what is now known as the *degree of urbanization*. This method by using both the population size and the population density, classifies the entire territory of a country into grid cells of 1km$^2$ which can belong to three main classes:

- *Urban Centres*, when there are at least 50,000 people living in the area and a population density of minimum 1,500 people per square kilometre (km$^2$).

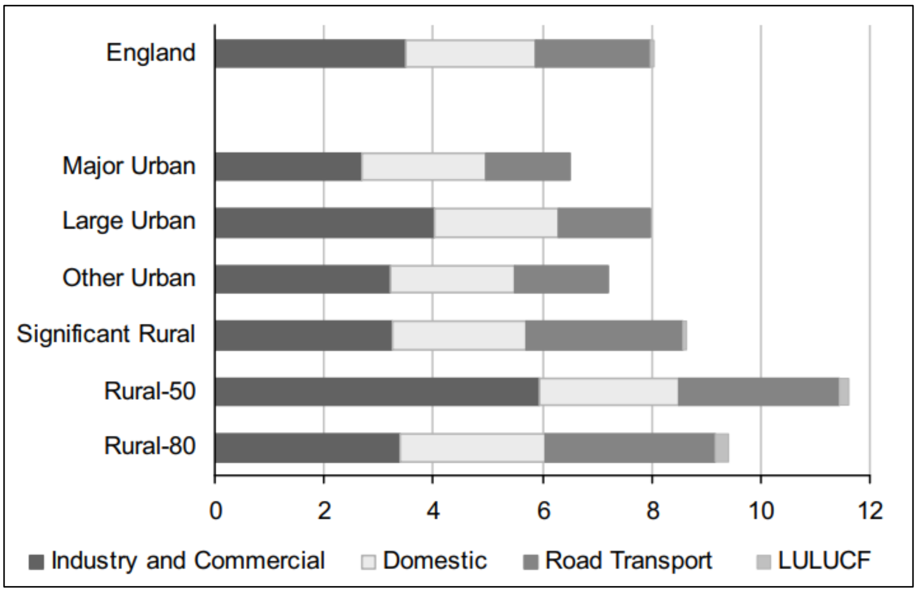
- *Urban Clusters*, when there are at least 5,000 inhabitants and a population density of at least 300 people per square kilometre ($km^2$).
- *Rural areas*, when there are less than 5,000 people living in the area.

However, many researchers criticise also this criterion, as they believe it highly overestimates the level of urbanization of an area. In fact, we can see that while the previously used OECD, EU and UN instruments estimated that roughly 55% of the population lived in urban areas (United Nations, 2019), according to these results, a staggering 85% of the world population would be living in urban area (considering both urban centres and urban clusters). This is mainly because of the measure adopted by China and India. Because of the large population size of these two countries, they alone account for half of the difference in rural population and due to the fact that, for instance, China considers an area urban only if it has more than 100,000 inhabitants, by considering each national measure, rural areas result in being a lot more. Nevertheless, for the scope of this research, the indicator describe above will be used when classifying urban and rural areas.

Regardless of what indicator is used, one thing is certain, delivering services in rural areas is almost always more challenging compared to delivering them in urban locations. This means that these services will either not be offered at all, or they must be offered at higher prices or different qualities in rural areas, limiting the adoption rate by the local residents, and often depend on public intervention more than urban services. This, deeply limits the effectiveness of car sharing, especially as cars are most intensively used by drivers living in a small town and suburban area of a large city (Kołsut & Stryjakiewicz, 2022; Stentzel, 2016), and the costs, travel time and carbon emissions resulting from transport tend to be higher in rural areas (Pateman, 2011). A study by Pateman (2011), analysed some of the main statistical differences between urban and rural United Kingdom. In this research, urban and rural areas were sub-divided into three categories each according to population size and density. In the section about carbon emissions, Patemen (p. 60) stated that "carbon emissions in England ranged from 6.5 tonnes per person in 2008 in *Major Urban* local authority areas to 11.6 tonnes per person, per year in *Rural-50* areas, compared with an England average of 8 tonnes. […] However, Road Transport represents the key rural/urban difference, with carbon emissions ranging from 35 to 47 per cent above the England average in rural areas" (see Figure 5). Higher emissions in rural areas coming from Road Transport can be seen also in Wales, Scotland and Northern Ireland.

**Figure 5**

*Carbon emissions per person (tonnes) in England: by area type, 2008*

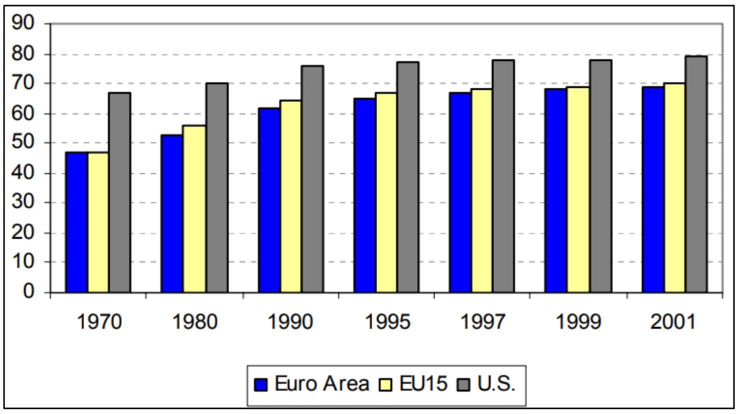



*Note. The figure shows how each person in rural or urban areas contributed to the overall production of greenhouse gases in England in 2008, with particular regard to road transport (second section from the right). The aim of this figure was to remark that people living in rural areas create more transport emissions than their urban counterparts. The figure was retrieved in November 2022 from Pateman, T. (2011). Rural and urban areas: comparing lives using rural/urban classifications. Regional Trends, 43(1), 11–86. [https://doi.org/10.1057/rt.2011.2](https://doi.org/10.1057/rt.2011.2)*

In the past, the separation between rural and urban areas was generally accepted by both society and the government. The fact that services were not offered equally in both areas was acknowledged, but also agreed upon. Those living in the rural countryside, were usually land workers that could not enjoy to the same quality of life of those living and working in cities. However, since then, society and quality of life have progressed, reducing the social distance between rural and urban people and creating similar expectation of quality of life. Nowadays, the service sector has gained a dominant role in developed economies, accounting for more than 70% of employment and value-added (OECD, 2005; ECB, 2006), ultimately growing to represent a key role in the life for both urban and rural residents (see Figure 6).

**Figure 6**

*Shares of employment from services (1970 – 2001) in the Euro Area, EU15 and U.S.*




*Note. This graph shows the percentage of employment coming from the service sector, 100% being the total employment over all sectors. It is shown to represent how important the service sector has become over time, standing for around 70% of total employment in the EU and approx. 80% in the U.S. in 2001. This figure was retrieved in November 2022 from Agostino, A., Serafini, R., & Ward-Warmedinger, M. (May, 2006). Sectoral explanations of employment in Europe the role of services. (No. 625).* [https://www.ecb.europa.eu/pub/pdf/scpwps/ecbwp625.pdf](https://www.ecb.europa.eu/pub/pdf/scpwps/ecbwp625.pdf)

This has led urban residents to also demand access to a broader range of services. However, according to the OECD report on the service delivery challenge in rural areas (2010), normally it's still possible to find scarcer and weaker services in rural areas compared to urban regions, independently from whether these are offered by public or private entities. This has created increasing concerns among scholars, policy makers and practitioners on finding solutions to this pressing issue.

When looking at the literature, car sharing is not the only sector in which this divergence is evident. Scholars have studied the urban-rural divergence for many years now, extending the research across many sectors and countries. Safdar et al., (2022, p. 1), studied the urban-rural gap in the academic competences of scholars and how cloud-based virtual learning environments may help mitigate this gap. According to their research, "students from urban areas are more likely to join higher education institutes in comparison with their rural counterparts, [due to the fact that] students from urban areas can benefit from highly qualified teachers and enjoy state-of-the-art facilities in contrast with their rural counterparts." Whyte (2010) provided a general overview on the urban-rural gap in China focusing mainly on the existing gap in health care services. The author even went as far as to say that there are two different societies in China, those living in cities, and those living in rural areas. This can be reconnected to the idea of critical mass that will be explained better in chapter 2.5. Byun, Irvin and Meece (2015), analysed the rural–urban differences in college attendance patterns and found significant differences in attendance of selective institutions, entry time to post-secondary education and continuity in enrolment among rural and urban students. They believe that the reasons behind these results are connected to the differences in the socioeconomic status and high school preparation of rural students. Pong, DesMeules and Lagacé (2009), conducted a cross-national study to analyse the divergences in health conditions between people living in urban and rural areas and their results proved that there is a noticeable difference between the two, with the second having a poorer health status than the first. They also demonstrated that such divergence is not strictly related to the Canadian context but can also extend to other countries. Yan et al. (2012) distinguished between rural and urban road safety, and they found that crashes increased as volume of cars driving increased, although it lowers the severe crash occurrences, and that urban areas have a higher crash risk. Cutter, Ash and Emrich (2016) analysed the disaster resilience divide between urban and rural areas of the United States and they discovered that, because of the variability in the main instruments for disaster resilience among urban and rural locations, the resilience progress cannot be achieved by using a one-size-fits-most strategy. Hollman, Obermier and Burger (2021) analysed the rural-urban digital divide and conclude that rural areas face a digital inequality compared to urban areas due to the lower quantity of subscribers and demand. They then go on to say that the digital divide can easily be observed in situations where "rural consumers of ICT [Information and Communications Technology] often pay rural penalties, such as, higher prices, lower bandwidth, lack of reliability, few service provider choices, or no broadband service options at all" (Hollman, Obermier, & Burger, 2021, p. 176). A study conducted by Roos (2006) on over 50 Germany cities, found that price levels were shown to be clearly different. According to the researcher, the key variables influencing this divergence were population size and density and the average wage level. Finally, according to Visagie and Turok (2021), the urban-rural gap has widened even more due to the Covid pandemic which has increased the inequalities between cities and rural areas. A similar conclusion was provided also by the OECD (2010), who believe that following the 2008 financial crisis and the limited budgets for public expenditures, urban areas would be preferred over rural areas when allocating funds, putting at serious risk the availability of services in rural regions. These are just some of the examples of the ongoing research regarding the urban and rural divergence. However, up until now, to the knowledge of the author, limited research has been done on the urban-rural gap in car sharing, and fewer still, if not any, has studied how changes in price affect critical mass.

This research, together with empirical evidence provided by several governmental, intergovernmental and private institutions and organizations (e.g., EU Commission, OECD, Statista, etc.), has allowed to establish that providing services is particularly challenging in rural setting because of “lower density populations, larger distances that have to be travelled by service users and service providers, and the small numbers of people in any location that preclude economies of scale. This makes delivering any service more expensive in a rural location than in urban centres” (OECD, 2010, p. 3). Higher costs means that these will have to be born either by the customers through higher prices, which reduces their demand, or by the firm, which reduces its profits and thus their willingness to take a business risk. This is particularly true for private services, where, according to the theory of risk and rationality, services will be offered only in circumstances where there is a satisfactory likelihood that the entrepreneurs will make a profit from their operations. Rational decision making and risk are strongly connected and are present in every entrepreneurial decision. The theory ultimately comes down to desire of the entrepreneur to maximise the expected utility when decision have risky payoffs (Miller, 2007). However, limited potential customers, such as the ones found in rural areas, means more risk, so decision makers want to be sure that there is enough demand to cover the costs of supplying the service (OECD, 2010). It is therefore essential to understand the critical mass of any service-based business before venturing into a rural endeavour and it is then even more important to understand the required number of residents necessary to reach the critical mass. Such a framework was provided by Saglia, Wagner and Dion (2022), in their study “ “, in which the researchers take empirical values of costs and prices, coming from several operating car sharing businesses, and they use them to calculate the break-even point of a car sharing provider. They then use, what they call, expected use of service (*EUS*) and the existing alternative equivalent services (*AES*) to calculate for different population sizes, the likelihood of a company to reach its critical mass. According to their results, on-site services cannot operate, or will fail shortly after launch, if they do not reach their critical mass. Population size and population density, often dictates whether a service can be offered at all or at what price level it can be provided. This creates a clear distinction among urban and rural settings, because rural areas dispose of smaller populations, which makes it harder for car sharing companies, and other on-site service companies, to reach their critical masses. Silberer et al. (2022), similarly believe that rural areas face inequalities when it comes to car sharing because of sparse populations. In fact, they discovered that although consumers in rural areas are open and willing to use car sharing services, it is empirically evident that they have several limitations to do so. Price and availability are the major factors responsible. Among large German cities with more than 100,000 inhabitants, 95% offer car sharing, while only 4% of cities with less than 20,000 inhabitants have car sharing services at their disposal (Silberer et al, 2022). This is even more evident with free-floating car sharing, which is only available in 34 major German cities such as Berlin and Munich. This ultimately resonates in rural residents having less access to car sharing services. Therefore, over 80% of private customers of car sharing services live in either the city centre or in densely built neighbourhoods surrounding the city centre. 12% of private customers can be found in neighbourhoods outside the city centre, and only 5% come from peripheral neighbourhoods (Loose, 2010), as can be seen in Figure 7.

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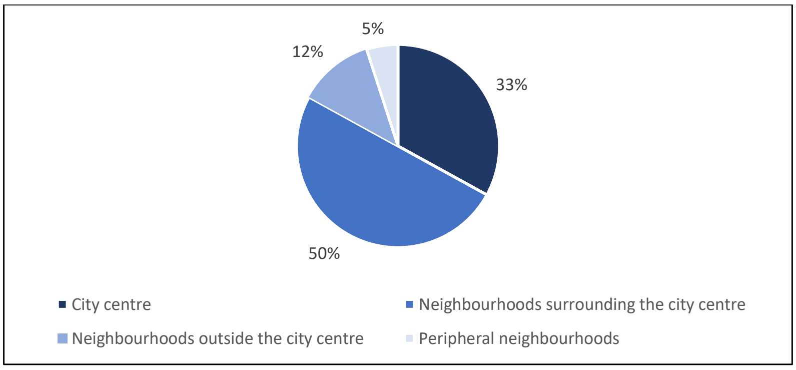
**Figure 7**

*Distribution of private customers of car sharing services by residential area (2010)*




*Note. This pie chart shows who, among private consumer, is using car sharing services. As can be seen people living in the city centre and near the city centre are the most frequent users (83%), and the further out we move from the city the less people use car sharing services. This chart was shown to remark how little access and how few users in rural areas use car sharing. This figure is a personal interpretation of data coming from of Loose, W. (2010). The state of European car sharing. Project Momo Final Report D, 2, 1-119.* [*http://www.car-sharing.info/images/stories/pdf_dateien/wp2_report__englisch_final_2.pdf*](http://www.car-sharing.info/images/stories/pdf_dateien/wp2_report__englisch_final_2.pdf)

Clearly there can also be other reason that influence the limited availability of car sharing in rural areas. For instance, car sharing necessarily works as a complementary service to public transport, cycling, and walking (Migliore, D'Orso, & Caminiti, 2020), therefore, because public transport is less available in rural regions compared to urban area (Šipuš & Abramović, 2017; Šťastná & Vaishar, 2017; Wappelhorst et al., 2014), car sharing is less likely to work in rural locations. Additionally, it was found that "generally speaking, people in areas with low population densities tend to rely more on cars and less on public transport than their more urban counterparts and are therefore more likely to have the option of switching to car travel if fares rise" (Paulley et al., 2006, p. 298). Celsor and Millard-Ball (2007, p. 1) found that "low vehicle ownership has the strongest, most consistent correlation to the amount of carsharing service in a neighbourhood". Combined with the research by Paulley et al. (2006), who discovered that rural residents tend to have a higher vehicle ownership than their urban counterparts. It is possible to conclude that, car sharing may be more successful in urban areas, because people own fewer cars and are more dependent on public transport. Also, age may influence the adoption rate of car sharing services, for instance older people tend to drive less and move less than younger people. Consequently, because rural places tend to have older populations (OECD, 2010; Pateman, 2011) compared to urban areas, less people may be willing to use these services which negatively affects the willingness of entrepreneurs to open a car sharing business in these places. On the other hand, younger and more inexperienced drivers may lead to more accidents (Borowsky, Shinar, & Oron-Gilad, 2010; Ortiz et al., 2018), with research showing that urban areas face much higher crash risk, which may lead to more damaged vehicles, which increases the cost of the provider. Many other aspects can also be considered, such as crime rates and vandalism rates being higher in cities, which may potentially increase costs of car sharing providers, however, as mentioned at the beginning of this section, lower density populations, larger distances that have to be travelled by service users and service providers, and the small numbers of residents that preclude economies of scale, can be seen as the main reasons behind the urban-rural divergence. All other aspects may affect in some way the willingness to offer a car sharing service in a particular area or not, however their influence is minimal compared to the three just mentioned.

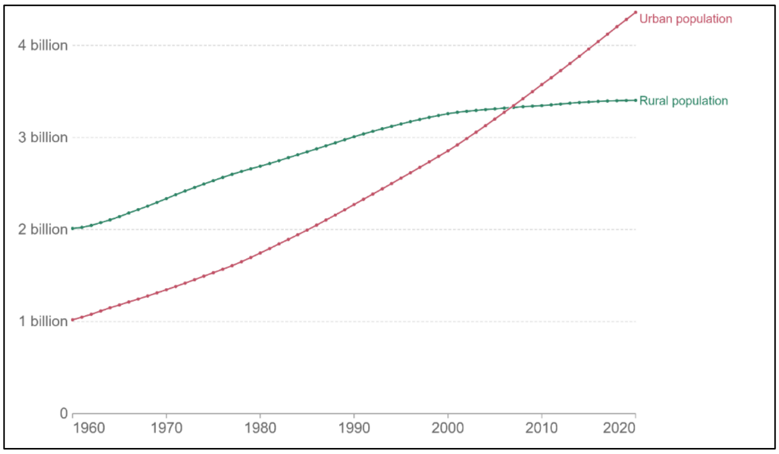
#### 2.4.1. Lower Population Density

Although for most of human history, people lived in small communities scattered across the globe, nowadays more than half of the population lives in urban areas. In the 1800s

90% of the population still lived in rural areas (World Bank, 2020) and in 1960, more than double of the population globally lived in rural areas, however, according to the United Nations (2019) and the World Bank (2020), approximately 55% of the population, which accounts to 4.3 billion people, now lives in urban areas (see Figure 8). This is the highest peak of urbanization ever registered in human history.

**Figure 8**

*Number of people living in urban and rural areas across the world, 2020*



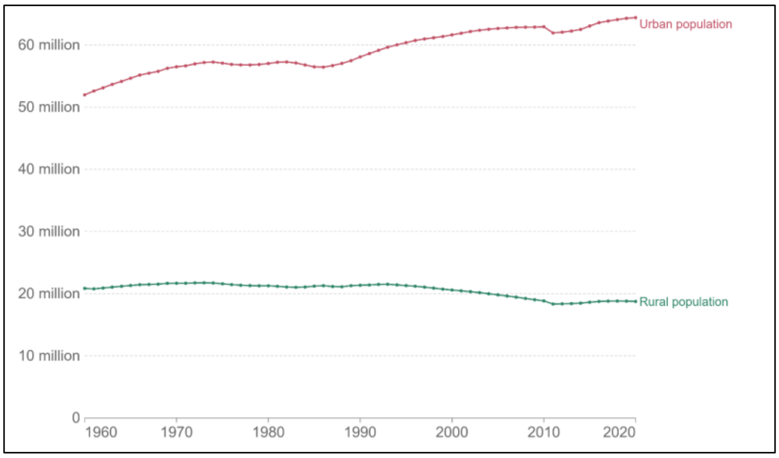

*Note. This figure represents the global population size between 1960 and 2020, distinguished among those living in urban locations (red) and those living in rural areas (green), according to the UN definition of urban. Since 2007, more people have started living in urban areas than in rural areas. The trend in urban population growth is clearly positive, creating expectations of further growth, while it is possible to see that the population growth in rural residents has reached a sort of plateau. The aim of this image was to show how the role of the two areas has inverted, once rural areas were predominant, however, nowadays most people are choosing to live urban locations than in rural ones. That said, 3.4 million people still live in rural areas, making it a major area to consider. This figure was taken on November 2022 from Ritchie, H., & Roser, M. (2018). Urbanization. Our World in Data.* [*https://ourworldindata.org/urbanization*](https://ourworldindata.org/urbanization).

This is particularly true when looking at the European situations. For instance, data retrieved from Statista (2022), shows that urban population in Germany was nearly 80% in

2022, while rural population was approximately 20% of the total population (see Figure 9). Germany was already a particularly urbanized society back in the mid-1900s (71%), however since then the urban population has continued to grow constantly and, maybe more interestingly, the rural population has actually decreased in size as people have moved out of the countryside to go and live in cities.

**Figure 9**

*Urban and rural population share in Germany from 1960 to 2022*

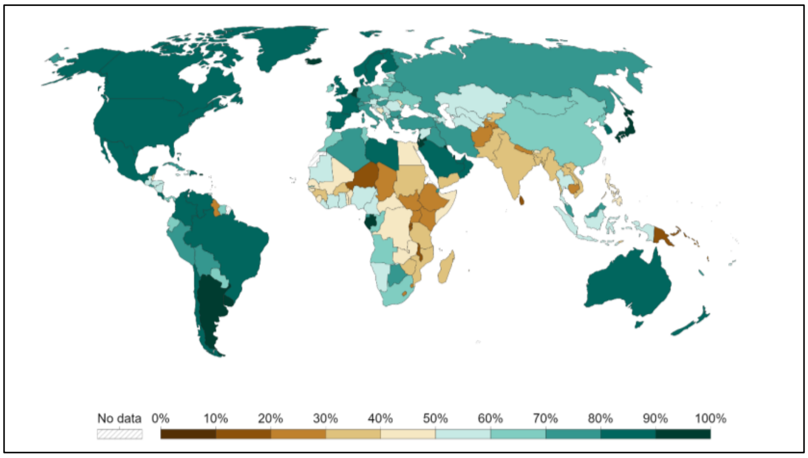



*Note. This figure shows the distribution of the German population between rural (green) and urban (red) residents from 1960 to 2020 according to the UN definition. It was chosen to show, not only that the urban population is much bigger than the rural population, but also that the distance between the two has had a growing trend in the last 60 years. The figure was retrieved in November 2022 from Ritchie, H., & Roser, M. (2018). Urbanization. Our World in Data.* [https://ourworldindata.org/urbanization](https://ourworldindata.org/urbanization).

However, this extends well over just Germany. According to Statista (2022), in 2021 less than 20% of the population in high income countries and around 35% of people living in low-income countries, lived in rural areas (see Figure 10). This trend is expected to continue growing in the future due to rising incomes and shifts away from employment in agriculture (Ritchie & Roser, 2018), meaning that more people are deciding to live in an urban setting rather than rural locations.

**Figure 10**

*Share of populations living in urban areas, 2020*




*Note. This image shows what level of urbanizations countries have around the world as of 2020, according to the UN definition of urban. It is possible to see that North America, South America (with the exception of Guyana), Europe (especially Western Europe), most countries of the Middle East and Oceania, have particularly high levels of urbanization. Only Central and Eastern Africa, together with South and South-East Asia have comparatively low values of urbanization. There seems to be a pattern between the economic development of a country, and its level of urbanization. The more developed countries tend to be more urbanised and vice versa. This image was taken on October 2022 from Ritchie, H., & Roser, M. (2018). Urbanization. Our World in Data. https://ourworldindata.org/urbanization.*

As more people move to cities, population density in urban areas grows (and most likely rural density decreases). In the simplest of scenarios, population density can be defined as the number of people per unit area (McArdle, 2013). In other words, it represents how many people live in a certain area, which can be found by doing:

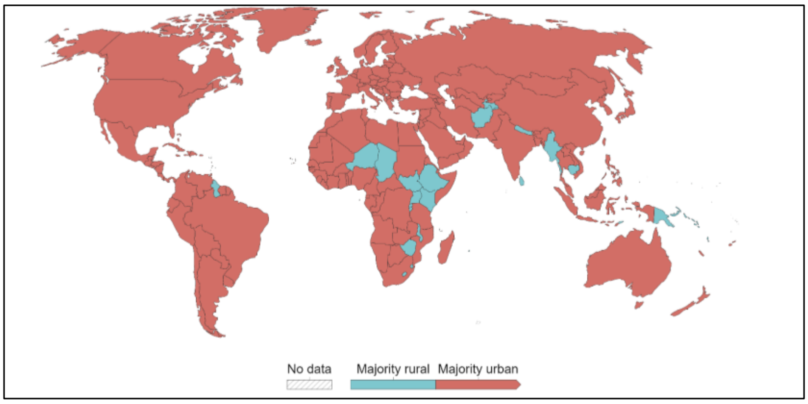
$$\textit{Number of people / area they occupy = population density} \quad [1]$$

As population density is often included in the actual definition of urban area, it can always be deducted that urban density is higher than rural density. So, in rural areas residents tend to live in more dispersed areas across the region, making connectivity harder. Because people live further away from each other, it is harder to have "central spots" in which to make the car sharing vehicles available, meaning that either more service areas are made available, which increases noticeably the providers costs, or people and staff will have to travel longer distances to use the service (OECD, 2010).

This trend is expected to keep on growing in the future. The United Nations (2019) and the World Bank (2022) estimate that by 2050 more than two thirds (68%) of the population will be living in highly dense urban areas and by then there will only be very few countries in which urban inhabitants are lower than rural inhabitants (see Figure 11). This means that over 7 billion people will live in urban areas.

**Figure 11**

*Are nations going to be more urbanized or more rural? (2050)*




*Note. This map shows if by 2050 countries around the world will be more urbanized (red), so over 50% of the population will live in urban areas, or if people will still live predominantly in rural areas (blue). As can be seen from the image, most countries will be mostly urbanized, with a few exceptions especially in Sub-Saharan Africa. The aim of this figure was to remark how important urbanization is expected to become in the next few years. This image was taken on November 2022 from Ritchie, H., & Roser, M. (2018). Urbanization. Our World in Data. [https://ourworldindata.org/urbanization](https://ourworldindata.org/urbanization).*

According to Celsor and Millard-Ball (2007), "high population density brings a large customer base within walking distance of each carsharing location. Doubling density doubles the potential customers for a given carsharing location". Therefore, population density is a good indicator of the potential customer base for a carsharing location, meaning that cities and urban areas are more suited for car sharing success, than rural regions.

#### 2.4.2. Longer Distances Travelled

Within the concept of rurality, there is imbedded the idea of distance from major urban cities. According to the OECD (2010), the spatial distribution of rural populations is a characteristic that makes service delivery difficult. While some customers might be willing to travel considerably to use a service, this is not the typical situation. As a result, car sharing providers may not be able to reach a big enough customer base for it to achieve its critical mass (OECD, 2010). This is particularly true, when considering that rural residents would most likely have to use public transport to reach the location in which car sharing is offered because, as it was previously mentioned, public transport is lacking in both availability and quality in many rural areas. The added travel cost and time will make it more expensive for people to use the service, and therefore limit the willingness to use it. Accessibility to rural areas becomes more difficult also for service providers (e.g., more expensive to get staff there, petrol is generally more expensive in rural areas, higher unproductive staff time to travel longer distances, fewer mechanics in the area lead to more down time of the broken vehicles, etc.), increasing transportation costs and overall costs to provide services in rural areas (Asthana et al., 2003). For instance, the higher demand of shared cars in urban areas compared to rural areas, means that cars left in rural areas must be brought back to urban areas in order to be able to meet demand. However, unlike bikes, cars can be moved only one at a time, requiring a large group of relocation workers which increases operating costs (Stagg, 2019). These distances also limit access to necessary services such as cleaning services, vehicle checks, staff training, other support services. This decreases the providers potential profits and as a result increases the risk propensity of starting a business in that area.

**Kommentiert [SM3]:** Do I need to cite it here again although I did it above?

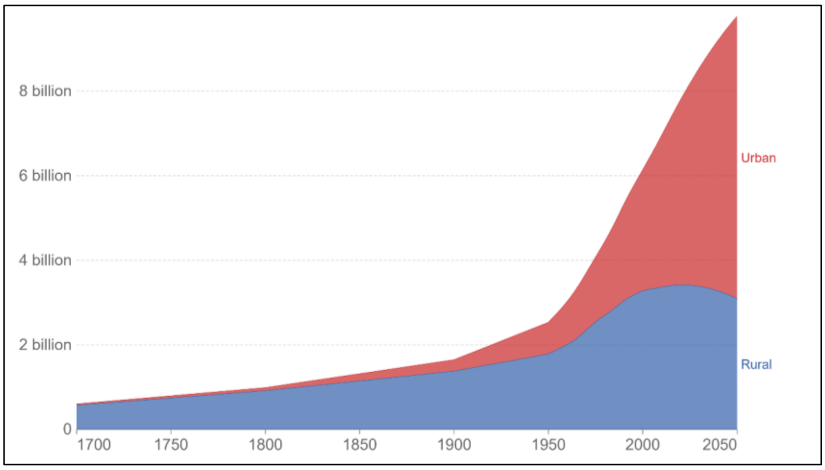
#### 2.4.3. Smaller Customer Base

Lagadic, Verloes and Louvet (2019), believe that car sharing success depends on the ability of the provider to reach a large number of users for each car, which is strictly linked to the population density. However, according to the researcher, high population density is hard to find outside urban areas, “that is why B2C carsharing services often remain concentrated in the city centre, except when they receive public subventions” (p. 74). As can be seen in Figure 12, according to the United Nations, fewer people can, and will, be found in rural areas compared to urban locations. Less people can lead to a smaller customer base if adoption rates remains constant. Consequently, a lower customer base means lower possibilities of economies of scale (Asthana et al., 2003).

Economies of scale "refers to the phenomenon where the average costs per unit of output decrease with the increase in the scale or magnitude of the output being produced by a firm" (Khemani & Shapiro, 2003, p. 39). This is possible, because certain costs stay fixed, regardless of the quantity that is being produced (Dauphiné, 2017). Therefore, a smaller customer base reduces the possibility of economies of scale. According to Asthana et al. (2003), because of economies of scale, unit costs in small communities like those found in rural areas tend to be considerably higher than in large ones. This is made worse by the non-storability factor of services. Unlike physical goods, where manufacturers can keep excess production in the inventory, service are not readily storable. Storability allows to build up the inventory when demand is low and use it when demand is high, which allows companies to work on a stable basis even if demand fluctuates. Without the possibility to store products, like in the case of services, demand fluctuations can lead to excess capacity that is wasted and/or inadequate capacity which leads to missed profits. In either case, surges and drops in resource use represent added cost for car sharing providers (OECD, 2010). However, a small customer base does not only allow for lower economies of scale, the low population density of rural regions make it also hard to achieve critical mass. Therefore, "rural and urban divergence may be explained through critical mass." (Saglia, Wagner, & Dion, 2022, p. x).

**Figure 12**

*Urban and rural population size development, 1700 – 2050*



*Note. This figure represents the global population size between 1700 and 2050, distinguished among urban (red) and rural areas (blue) according to the UN definition. As can be seen, in the 1700s, urban population was basically inexistent, but started to develop in the 1800s and 1900s. At the beginning of the year 2000 rural population was still great than the urban one, however, since 2007 urban population overtook the rural population in size. Since then, the urban population has continued to grow, and this trend is expected to increase also in the future. In 2050 the United Nations expect there to be 9.77 billion people on the earth, of which 6.68 will be living in urban areas and 3.09 will be living in rural settings. This was taken on November 2022 to show how, given constant adoption rates, there will be a much higher customer base in urban areas than in rural areas. Source: Ritchie, H., & Roser, M. (2018). Urbanization. Our World in Data. https://ourworldindata.org/urbanization.*

According to Staff (2019, p. 1), low demand areas, such as rural towns, "limits the efficiency and profits from the service provider's side, and finally causes the operation into a negative loop."

Additional proof of the urban-rural divergence comes from the *basic central place theory* (Hsu & Zou, 2019). This theory was developed originally by Lösch and Christaller to organize cities and the nearby rural areas. Urban centres are seen as the focal points that need to be developed according to urban-industrial necessities (Ramírez, 2009). Further developments of the theory suggest that the number of services and service providers increases proportionally with the size of the place where they are offered. This means that larger places have an advantage as far as services are concerned (OECD, 2010). This is the result of economies of scale and distances. According to research on geographical planning, each product has its own *range*, which refers to "the maximum distance that the consumer accepts to travel in order to purchase this good" (Dauphiné, 2017, p. 120). Therefore, firms aim to occupy locations that are central to their markets that minimize the travel costs for consumers (Mulligan, Partridge, & Carruthers, 2012).

**Kommentiert [SM4]:** Do I need to cite them even if I don't use their publications?

Following the basic central place theory and with strong influence from Myrdal, Hirchmann, and Rostow, John Friedmann developed a model based on four main stages. The first stage presents multiple independent rural areas, which do not have any form of exploitation or hierarchy among them. A second phase sees a concentration of investments in one or two central locations, following a growth of industrialization and intensive development, while

**Kommentiert [SM5]:** Do I need to cite them even if I don't use their publications?

the other areas present a stagnant or declining economy. The concentration of wealth in the centres, the increasing poverty in the periphery and the overall growing regional disparities, marks the main characteristics of the third phase. The fourth and final stage sees the prevalence of an independent system of cities at the national level that exploit peripheral areas for their resources (Ramírez, 2009).

**Kommentiert [SM6]:** Is it clear or is it still too complicated?

According to Mulligan et al. (2012), when there are network effects and economies of scale, the central place theory has gain importance among policy makers and other actors, to facilitate the provision of services, infrastructure, and economic development in both urban and rural areas. According to the researchers, rural areas have a lot to profit from working with urban areas. The best economic development strategy for rural areas may be to increase the quality of life they offer, to attract urban residents and commuters that are already bound to these areas (Ali, Olfert, & Partridge, 2011; Castle, Wu, & Weber, 2011; (Partridge & Olfert, 2011). However, more detail on the implications for policy makers will be provided in chapter 2.6.

## 2.5. Critical Mass and Required Number of Residents

Originally, the term *critical mass* comes from studies in nuclear physics, where it refers to the quantity needed to start a chain reaction that leads to a new situation or process (Goertzel, 1956; Goldschmidt, 1972; Goldschmidt & Quenon, 1970; Otsuka, 1964). The term was then adopted during the 1990s and early 2000s by researchers analysing the field of collective action movements (Centola, 2013; Macy, 1990; Naylor, 1990; Oliver, Marwell & Teixeira, 1985) and soon after was used to support studies related to women's political representation and stress the importance of attaining a certain percentage of women in political assemblies, in order for women to make a substantial difference in politics (Childs & Krook, 2008; Dahlerup, 2006; Funk, Paul, & Philips, 2021; Jaquette, 1997; Studlar & McAllister, 2002; Tremblay, 2006; Yang, Yang, & Gao, 2019). In the last two decades, the term has been reallocated to a more business related setting and, in particular, it relates to the necessary number of customers/users needed to successfully launch a new business or product, allowing the backers to be financially viable (Evans & Schmalensee, 2010; Huang & Duan, 2012; Markus, 1987; Zhou & Li, 2018). This allocation finds its roots in the work by Economides and Himmelberg back in the mid-1990s, who were among the first developers of this definition of critical mass and, according to their view, many platform-based goods or networks that face network externalities[2], require a critical mass. The researchers define this critical mass as "a minimum network size that can be sustained in equilibrium, given the cost and market structure of the industry" (Economides & Himmelberg, 1995, pp. 1-2). No equilibrium market could exist for a good or service, unless the customer base is greater than the critical mass point and, because the introduction of new products or technologies to a market usually requires a high critical mass, small market coverage is difficult to exist. Either the good is adopted by many people and has significant coverage, or it will fail in a brief time and not exist any longer on that market (Economides & Himmelberg, 1995). Additionally, the term is also used by many researchers when talking about innovative technology adoption rates (Kapoor et al., 2022; Keser, Suleymanova, & Wey, 2012; Lou, Luo, & Strong, 2000; Moghavvemi et al., 2020; Van Slyke et al., 2007). However, most late studies on critical mass in the business and technological adoption perspective have obtained purely theoretical explanations of why some markets exhibit the critical mass phenomenon and very few have given empirical evidence of why such constraint occurs (Zhou & Li, 2018) and fewer still have used realistic market data to estimate a potential critical mass.

In this research, *critical mass* will follow the idea brought forward by Economides and Himmelberg (1995) and will be considered as the minimum number of customers or sales needed to achieve a certain goal, which is often profitability or coverage of starting and operating costs (Evans & Schmalensee, 2010). In other words, critical mass may be seen as the break-even point of service-based companies, which require a minimum number of users to be at least able to cover the costs for offering the service (Cafferky & Wentworth, 2014).
Saglia, Wagner and Dion (2022), used the concept of critical mass, applied to the field of car sharing, to prove the divergence between rural and urban areas. According to their results, because car sharing providers would not be able to reach their critical mass in many rural areas, these services, like many other, are not offered to rural residents. Cities and other urban areas, on the other hand, benefit from a much larger and more dense population, which allows car sharing businesses to reach their critical mass and therefor offer their services in the area. This creates a clear divergence in the number of available services for the two distinct areas, which proves that there is in fact a gap between urban and rural regions. This view is aligned with that of other researchers according to whom "large numbers of regular users are required for a CS [car sharing] network to become profitable" (Illgen & Höck,

[2] *Network externalities* are defined by Economides and Himmelberg (1995) as the situation in which the value of the good to the consumer depends on the number of consumers purchasing the same (or a similar) good.

2018, p. 1), and if critical mass cannot be satisfied, businesses fail (Evans & Schmalensee, 2010), or new technologies may not be able to reach acceptable levels of adoption and diffusion to cover the development costs (Economides & Himmelberg, 1995; Van Slyke et al., 2007; Zhou & Li, 2018). Moghavvemi et al. (2020), found that critical mass was an essential barrier in the adoption of mobile payment systems in Malaysia. Consequently, given the same willingness to use the service, areas with smaller population sizes make it harder for businesses to reach their critical mass if they must offer their services on-site, while areas with bigger population sizes make it easier for the same businesses to reach their critical mass. See, for instance, many platform-based services that require a minimum density of consumers to operate successfully, which is rarely found in rural areas (Zulauf & Wagner, 2021). Surprisingly even non-profit organizations usually have critical masses, as it would not be worth the cost if they could not reach and help a minimum number of people or other entities.

Following the study by Saglia, Wagner and Dion (2022), also in this research, critical mass represents a fundamental aspect necessary for being able to launch successfully a car sharing business. According to Lagadic, Verloes, & Louvet (2019, p. 1), "a major challenge remains [in the car sharing industry] in terms of finding the right business model[3] to reach the profitability threshold, especially outside of the dense centres of metropolis". Nevertheless, car sharing is used merely as an example and the author believes that these result, once adapted, may be representative of most platform based on-site service. In fact, the concepts used can easily be applied to other sectors and it is possible to state that if critical mass cannot be achieved, any platform-based service is doomed to fail (Plavčan & Funta, 2020) and therefore it represents a strong barrier for entering the market. However, as Saglia, Wagner and Dion (2022) demonstrate in their study, although critical mass is a fundamental notion to know before evaluating whether to start a car sharing business or not, this concept remains merely abstract and cannot be used in practice unless it can tell service providers the *necessary number of residents living in an area needed to achieve such a critical mass*, which the researchers shorten to *N*. In more simple terms, it would be close to useless knowing that 1,000 people/users are needed to cover the costs of running a car sharing business, if it is not known how many people need to live in the area in order for there the company to reach the 1,000 users they need to cover costs. If an entrepreneur were to offer a

[3] A business model, refer to "how a firm is able to earn money from providing products and services" (Boons & Lüdeke-Freund, 2013)

service in a highly dense location in which there were millions of people who lived close together, but no one was willing to use the service, it would still be impossible to achieve the necessary critical mass. Therefore, what is suggested is to first calculate the critical mass [2], and then use it to understand how many people need to live in the targeted area to make the business viable [3] (Saglia, Wagner, & Dion, 2022). The suggested formula to calculate the critical mass of a service-based company is (Yunker, 2006):

$$S_P = C_F / (P - C_V) \qquad [2]$$

where $S_P$ = services provided (which would normally be represented by $q$ for quantity), $C_F$ = fixed costs, $P$ = price, and $C_V$ = variable costs. This formula represents the break-even point for a service-based company. In other words, it stands for the volume of services than need to be offered at a given price, necessary to cover all costs (Hillier & Lieberman, 2009). This can also be considered, in some ways, as the critical mass of a service-based company. Critical mass is positively affected by fixed and variable cost and is negatively affected by price. Therefore, the higher the costs, the more will have to be sold to reach critical mass, while the higher price, the less will have to be sold to reach critical mass. To provide a more practical view to this issue, Autolib', one of the biggest car sharing providers in the world that which is based in Paris, declared in 2013 that it would have needed 50,000 registered users to become profitable. The threshold was increased by the company to 82,000 registered users in 2015 but, although Autolib' sold 111,331 one-year registrations in 2016, in December of the same year, the company announced that it predicted to achieve a breakeven only in 2017 or 2018 (Lagadic, Verloes, & Louvet, 2019). This example was told to show the necessity of accurately measuring a service providers critical mass, and how complicated this is. A big limitation of the thresholds provided above, were the element taken into consideration, number of registrations. It is exceedingly difficult to predict how many trips registered users will actually do, therefore, estimating $S_P$ appears to be a more reliable source of information.

**Kommentiert [SM7]:** Is this assumption correct? Where can I find somewhere to cite that says the same thing?

What Saglia, Wagner and Dion (2022) suggest doing next, is introduce two new essential variables to this result. These are: *expected use of service* (*EUS*), and *available equivalent services* (*AES*). *EUS* represents the number of times people in a determined area are expected to use the service. For instance, if in a location there are 100 people, but only 10 are expected to be interested in the service and plan to use it once per day, the *EUS* will be equal to 10%. On the other hand, the *AES* represents how many equivalent services are already existing in the area of interest. For example, if we are talking about car sharing and we know that there are already 500 cars available in the area, then the *AES* will be equal to 500. This is because people can choose indifferently between the services offered by one provider or the other and, because they are equivalent, they will choose simply the one that is closest to them. Once these two values have been calculated, the first through surveys, field studies or research and the second by analysis the existing market, they are added to the final formula, that will provide the number of residents needed to achieve the critical mass, *N*:

$$N = (S_P / EUS) \times AES \qquad [3]$$

where *N* represents the number of residents needed to achieve the critical mass. If we extend the formula above [3], we get that:

$$N = C_F / (P - C_V) / EUS \times AES \qquad [4]$$

Reaching a company's critical mass, however, not only allows it to cover its costs, but it can also lead to faster growth and to higher adoption rates of an innovative technology. Once a company has reached a wide number of users, it also receives more attention from other users and can benefit from referrals (Plavčan & Funta, 2020). This is connected to two main aspects: the network effect and the perceived critical mass. According to the so-called *network effect*, a platform-based businesses may be able to grow very rapidly, because users attract other users (Evans & Schmalensee, 2010), because the benefit that each consumer gets from a network-based good depends on the number of consumers who also own the same or similar goods. Therefore, following this idea, for a network good to be successful, it must reach the minimum number of buyers required to render purchase worthwhile. This is defined by some researchers as critical mass (Economides & Himmelberg, 1995; Ruffle, Weiss, & Etziony, 2015). For instance, MySpace, a precursory of Facebook and other social media platforms, grew to have more than two million users in its first year thanks to the strong network effect (Evans & Schmalensee, 2010). On the other hand, according to the notion of *perceived critical mass* (Lee et al., 2013; Lew et al., 2020; Kapoor et al., 2022), a person's adoption behaviour is affected by other individuals adopting the same technology or choosing the same product (Lew et al., 2020; Van Slyke et al., 2007). As observed by Lee et al. (2013), achieving critical mass indicates to others that the technology or product has become successful and has reached group acceptance. This has an important impact on subsequent adoption and usage patterns of the technology as choices of individuals often depend on their desire of be included and accepted by society. Once a platform has reached its critical mass, further rates of adoption become self-sustaining (Rogers, Singhal, & Quinlan, 2014).

These two aspects differ from each other, because in the first case a user receives more benefits if there are more people that enter the same network, while, in the second case, the perception of there being a lot of people using a good or technology creates more desire in using the same technology because it is seen as more successful and in order to adhere to societal standards.

However, it's possible to also say the opposite. If very few users show interest in the platform or technology, close to no attraction will be created towards it and there will be no network effect and people will perceive it as a non-successful product as the critical mass has not been reached. Additionally, if people consider the critical mass of a product too high compared to its potential customer base, this will reduce their own willingness of adopting the technology (Van Slyke et al., 2007). Therefore, consumers' expectations of low perceived critical mass may lead these expectations to be fulfilled (Economides & Himmelberg, 1995). This will lead towards a faster failure, which is emphasised by the easiness to switch between internet-based platforms (Evans & Schmalensee, 2010) and the possibility to adopt other technologies. Therefore, what Kapoor et al. (2022) suggest, is to use early adopters and opinion leaders in awareness campaigns to make potential users think that many people around them are using these new products or technologies. By doing so entities can increase positive feelings of perceived critical mass and increase adoption rates. For instance, according to the researchers, empirical evidence shows that a positive perceived critical mass plays a significant role in increasing the adoption rates found in the mobile-wallet market, by creating confidence in the mind of the consumer. Consequently, the more customers of mobile-wallets interact with others, the higher will be the probability of these people also adopting mobile-wallet (Kapoor et al., 2022).

**Kommentiert [SM8]:** Need to mention again?

That said, the main aim of this research though is not to describe and analyse how many people living in an area are needed for companies to reach their critical mass. The real aim of this research is twofold. This research wants to answer the questions:

1. How do price changes affect critical mass?
2. How do price changes affect the number of residents needed to achieve critical mass?

In order to see how different price levels affect *N*, all that needs to be done is to take the formula needed to calculate the *N* [4], estimate $C_F$, $C_V$, *EUS*, and *AES*, and leave *P* as an unknow variable, while *N* remains the dependent variable. Once the estimated variables have been calculated and added to the formula, by introducing once at a time the different price levels, it will be possible to see how *N* changes accordingly. More detail about this process will be provided in the methodology section in chapter 2.6.

However, it is important to notice that the estimated variable will have to correspond to realistic values found in small rural areas, if the aim is to know what price level would be needed to offer the service in a rural area. As the area of interest changes, all the variables will have to be adapted to the values of the new area taken into consideration. For instance, if a rural area in the outskirts of Berlin is considered, it is highly likely that cost level, expected use of service, and available equivalent services will be different from a rural area on the outskirts of Beijing, Palermo, Rio de Janeiro or San Francisco.

## 2.6. Influence of Price on Critical Mass

According to researchers, as costs fall and prices also reduce, critical mass increases and vice versa (Economides & Himmelberg, 1995; Cafferky & Wentworth, 2014; Yunker, 2006). By considering the basic profit function:

$$\pi = 0 = C_T - (\downarrow S_P \times \uparrow P) \qquad [5]$$

where $\pi$ equals profit. It is possible to see that if profit equals zero, then a higher price allows for lower services that need to be provided to cover all costs. In fact, the retail price plays a significant role on influencing the break-even moment (Jia et al., 2020). “With everything else left unchanged, the lower the price, the higher the brake-even point and vice versa” (Cafferky & Wentworth, 2014, p. 29). Following these results, the author hypothesises that, higher prices will allow car sharing providers to require a smaller critical mass and vice versa. However, the effect of a change in price on the number of residents living in an area needed to achieve this critical mass (*N*) is still uncertain, considering that change in price will most likely cause changes in demand and thus also in the *EUS*, following the rule of price elasticity of demand. When setting the price, manager must consider how customer behaviour might change if prices change (Cafferky & Wentworth, 2014). Also, it is important to keep in mind that if the price is excessively high, people will decide not to use the service, and the overall outcome of the market in the long run will be of non-adoption (Zhou & Li, 2018).

But why should an increase in price reduce critical mass? An increase in *P* will increase the value of the denominator and ultimately lower $S_P$, all else kept constant (Cafferky & Wentworth, 2014; Leen Streefland, 2012). Therefore, it is possible to conclude that price and critical mass have an inverse relationship; when one increases the other reduces:

$$\downarrow S_P = C_F / (\uparrow P - C_V) \quad [6]$$

However, when talking about the number of residents needed to achieve such critical mass, things are different. Saying that increases in prices will not affect the willingness of using the service is a big and quite unrealistic assumption. According to the rule of price elasticity of demand, when the price of a normal good increases, then demand reduces (Principles of Economics, 2016; Schneider, 2019). So, according to this rule, if the price of car sharing increases, then the willingness to use the service should reduce (Waserhole & Jost, 2016), and with it also the *EUS* (which is the denominator of the equation), thus increasing *N*:

$$\uparrow N = C_F / (\uparrow P - C_V) / \downarrow EUS \times AES \quad [7]$$

Staff (2019) found that the demand for car sharing vehicles depend on the users' attitudes, which can be influenced by many factors, including price. In particular, three main variables influence a users' vehicle reservation decisions: price, proximity and availability (Papu Carrone et al., 2020; Zoepf & Keith, 2016). Not surprisingly, Zoepf and Keith (2016) found that car sharing users derive the most utility from the service when they have a vehicle accessible when and where they need it, and at the lowest potential price. In other words, price, delayed time and distance from the user have negative coefficients, hence the utility that a user gets from a car sharing vehicle decreases as its price, delay and distance from the user increases. Therefore, a critical aspect to determine in this research is whether the price elasticity of car sharing is elastic or inelastic, or in other words, how responsive the quantity demanded is to changes in price, and what its effect is on demand and on *N*.

Price elasticity of demand is found as the percentage change in demand of a product or service, given changes in price (Principles of Economics, 2016). This can be written as:

$$\textit{Price elasticity of demand} = \frac{\%\ change\ in\ quantity\ demanded}{\%\ change\ in\ price} \quad [8]$$

Papu Carrone et al. (2020, p. 146), simulated the cost elasticities for substituting one transportation method with another among university students in Copenhagen and discovered that, unsurprisingly, “if the cost of free-floating car sharing decreases, the demand for car sharing increases while the demand for the other alternative modes decreases.” Therefore, it’s possible to say that car sharing acts as a normal good. These specific elasticities of each transportation method are presented in Table 1. In particular, the researchers focused on three main modes of transport and how changes in their price may reduce or increase their demand: private cars, public transport, and car sharing services. The cost elasticity was then calculated for each one of these three and divided according to which transport method the users switched to. If prices increase, users could choose to switch to private cars, public transports, bikes and car sharing services. In other words, the researchers conducted a price/cost cross-elasticity analysis[4] among several transport modes.

**Table 1**

*Cost cross-elasticity in transport modes, 2020*

| | Cost elasticities | | |
|---|---|---|---|
| | Car | Public transport | Car sharing |
| Car | -0.222 | 0.056 | 0.075 |
| Public transport | 0.042 | -0.340 | 0.219 |
| Bike | 0.032 | 0.117 | 0.102 |
| Car sharing | 0.061 | 0.280 | -1.060 |

*Note. This table shows the cost elasticity of four main types of transportation: private car, public transport and car sharing (rows), in relation to private car, public transport, bike, and car sharing (row). In other words, the table shows how a one percent increases in price affects the demand of these transport methods. However, it is important to consider that these elasticities refer strictly to the situation found in Copenhagen, where commuting methods are distinct compared to the rest of the world. For instance, cycling represents a much more important transportation method in Copenhagen (30%) than it does in other countries. Also, car sharing members in 2018 were much lower (in percentage) in Denmark (0.57%), than*

[4] A cross-elasticity analysis considers the effect that other modes of transport have on the demand of a particular mode of transport by estimating the demand elasticity for the competing modes with respect to the change in this mode (Paulley et al., 2006).

*they were in Germany (2.5%), although Copenhagen presents a much higher penetration rate of 4.34%. Personal elaboration from Papu Carrone, A., Hoening, V. M., Jensen, A. F., Mabit, S. E., & Rich, J. (2020). Understanding car sharing preferences and mode substitution patterns: A stated preference experiment. Transport Policy. https://doi.org/10.1016/j.tranpol.2020.03.010*

**Kommentiert [SM9]:** Eliminate the table?

What is of particular interest in this research, is the last column, which shows the elasticities of car sharing services. The elasticities shown in the table represent the condition where, an increase in 10% of the price of car sharing, would decrease the use of car sharing services by 3.96% in favour of other transportation methods. Specifically, it would increase the use of private vehicles by 0.75%, public transport by 2.19% and cycling by 1.02%. The same could be said for the opposite though. If car sharing prices would reduce by 10%, demand for car sharing would increase by 3.96% (Papu Carrone et al., 2020, Paulley et al., 2006). From this information it is possible to conclude that car sharing price elasticity of demand is equal to -0.396, because as seen from the formula above [6]:

**Kommentiert [SM10]:** Can we say this???

$$-0.396 = \frac{\%\ change\ in\ quantity\ demanded}{\%\ change\ in\ price} = \frac{-3.96\%}{10\%} \qquad [9]$$

However, one important limitation that needs to be addressed, is that the results are based off of an analysis conducted only on university students because, according to Papu Carrone et al. (2020), this allows to include in the survey individuals with a higher likelihood of using car sharing services. Additionally, the results represent the specific case of Copenhagen, where price elasticity of demand is most likely different from that of other cities and countries; and to calculate a more realistic price elasticity of demand of car sharing, also walking should be considered as a possible alternative to using car sharing. If prices increase people may also choose to walk instead of taking the more expensive shared vehicle. However, according to Ceccato and Diana (2018), although evidence suggests that car sharing can substitute private car trips, the same may not happen for biking and walking. This does not mean that walking cannot substitute car sharing, but it does indicate that not including walking as a possible alternative to car sharing remains a minimal issue, which does not distort results excessively. Nonetheless, to simplify calculations and considering the lack of a complete study analysing the elasticity of car sharing services in different cities, the result found by Papu Carrone et al. will be considered for the remainder of this research.

It is also interesting to see from Table 1, that individuals seem to be more sensitive to a change in the car sharing cost than to changes in cost of other transport method. According to Papu Carrone et al. (2020), this is not surprising due to the fact that the relative market share of car sharing is lower than the other transport methods, and the average user cost is higher. Additionally, from these results, car sharing appears to be used as a substitution of public transport. When the price of one increase, users mainly switch to the other method, while cycling and private cars appear to be less affected.

Many people chose their transport mode according to several factors, but costs represent the main element of consideration (Takahashi, 2017). Therefore, the price elasticity of demand of public transport may also be used as a *proxy variable*[5] to represent the price elasticity of demand of car sharing if no other data is available. This could be linked to the fact that, like public transport, car sharing can be seen as an alternative to car ownership (Katzev, 2003). Several studies have tried to analyse the price elasticity of demand of public transport, and most have reached similar results to those found by Papu Carrone et al. (2020). Davis (2021) analysed the price elasticity of demand for subways in Mexico and, although the researcher suggests that there is currently little evidence on this elasticity, particularly from low- or middle-income countries, he discovered that the price elasticity of demand for urban rail transit in Mexico ranges from −0.23 to −0.32. Yaman and Offiaeli (2022), studied the prices and demand of the London Underground. The researchers concluded that demand reacts differently to price increases than to price decreases and, in particular, that the price elasticities of demand ranged between 0.25 for price increases and 1.00 for price decreases. The researchers also gathered together the information coming from other recent studies regarding public transport elasticity and reported that all results found suggested values between -0.24 and -0.46. Wardman (2014) estimated that elasticities vary greatly by travel mode, area, purpose of travel, and time dimension (short or long run). Paulley et al. (2006) reported that bus-fare elasticities were approx. −0.4 in the short run and −1.0 in the long run, and that elasticities are affected by the time of day; off-peak values are about twice those in the peak. This is most likely the result of the purpose of the trip. Work and education trips tend to be during high-peak periods. Other researchers also found similar results, ranging between -0.25 and -0.8 for the short run price elasticity of demand, while the long run price elasticity of demand is generally much higher (Abrate, Piacenza, & Vannoni, 2009; Yaman & Offiaeli, 2022). Various other studies have been conducted throughout the years to estimate

[5] In the presence of an unmeasurable variable, it is very common in statistics to use a proxy variable, when the researcher believes that it is highly correlated with the unmeasurable variable (Frost, 1979).

the price elasticity of demand for public transport. Example of such studies and their results may be found in Table 2. In general, results vary between -0.3 and -0.5 and overall, metro price elasticities are higher than the price elasticity of demand for buses and the absolute value of peak-period elasticities are lower than off-peak ones (de Grange et al., 2013).

**Table 2**

*Short-term price elasticities of demand for public transport*

| Author | Transport mode | Area | Elasticity |
|---|---|---|---|
| Romilly (2001) | Transit, average | U.K. | -0.38 |
| Dargay & Hanly (2002) | Bus, average | U.K. | -0.35 |
| Paulley (2006) | Bus, average | U.K. | -0.42 |
| | Metro, average | U.K. | -0.30 |
| | Transit, average | U.K. | -0.44 |
| Holmgren (2007) | Transit, average | | -0.59 |
| Chen et al. (2011) | Rail, average | U.S.A. | -0.40 |
| Tsai, Mulley, & Clifton (2014) | Transit, average | Australia | -0.22 |
| Wardman (2014) | Rail, average | U.K. | -0.40 |
| Schimek (2015) | Transit, average | U.S.A. | -0.34 |
| Daldoul (2016) | Bus, average | Tunisia | -0.46 |
| Li et al. (2020) | Transit, average | Canada | -0.24 |

*Note. This table shows some of the most recent and most accurate estimations of the price elasticity of demand for public transport. The first column shows the author/s and year for publication, the second column shows the mode of transport in question, the third column lists the country in which the study was conducted, and the fourth column provides readers with the estimated elasticities. Personal elaboration from de Grange, L., González, F., Muñoz, J. C., & Troncoso, R. (2013). Aggregate estimation of the price elasticity of demand for public transport in integrated fare systems: The case of Transantiago. Transport Policy, 29, 178–185.* https://doi.org/10.1016/j.tranpol.2013.06.002 *and Yaman, F., & Offiaeli, K.*

*(2022). Is the price elasticity of demand asymmetric? Evidence from public transport demand. Journal of Economic Behavior & Organization, 203, 318–335.* *https://doi.org/10.1016/j.jebo.2022.09.005*

Although the areas in question and the transport modes vary for each study, by conducting a meta-analysis[6] and pooling together the average of the results found by the different empirical studies that were listed in Table 2, it is possible to conclude that the price elasticity of demand for public transport is on average -0.378. This result reinforces the results found by Papu Carrone et al. (2020) according to whom, the price elasticity of demand of car sharing is -0.396. This confirms the similarity between car sharing and public transport price elasticity and therefore the possibility of using public transport price elasticity of demand as a proxy variable for the price elasticity of demand of car sharing.

Once the price elasticity of demand of car sharing has been estimated, it is possible to analyse its effect on *N*. Considering the price elasticity of demand found above [8], and the formulation needed to find the correct number of residents needed to achieve critical mass [4], it is possible to say that a change in price in the car sharing industry, would have the following effect on *N*:

$$N_E = [C_F / (P_2 - C_V)] / EUS_E \times AES \qquad [10]$$

where $N_E$ represents the number of residents need to cover all costs considering the price elasticity of demand, $P_2$ is the new price, $P_1$ is the original price, and $EUS_E$ is the new expected use of service given the change in price and considering the price elasticity of demand. $EUS_E$ can be calculated by doing:

$$\frac{X - EUS}{EUS} \times \frac{P1}{P2 - P1} = e_D \qquad [11]$$

where $e_D$ stands for the price elasticity of demand, and X represents the unknown variable, which is $EUS_E$. This formula offers the adjusted expected use of service, considering the price elasticity of demand.

**Kommentiert [SM11]:** Is it okay if I don't have a theoretical or academic backing for this conclusion? I don't know if it has ever been done before, and in some ways it is my contribution to scholarity and my research.

For instance, considering a hypothetical situation where the critical mass $[C_F / (P_2 - C_V)]$ for a car sharing provider is 100, given $P_1$ = 10, $P_2$ = 12, $C_F$ = 1,000, $C_V$ = 2, $EUS$ = 4%, $AES$ =

[6] A meta-analysis is a statistical technique that is used to combine the results coming from different sources regarding similar topics, to create a single, more precise estimate of an effect (Aggarwal & Dhurkari, 2023).

10, and $e_D$ = -0.396, how would the increase in price affect the necessary number of residents needed to achieve critical mass (*N*)? According to the formulas above [9] [10]:

$N = 31{,}250 = [1000 / (10 – 2)] / 0.04 \times 10$

$EUS_E \rightarrow \frac{X-0.04}{0.04} \times \frac{10}{12-10} = -0.396 \rightarrow \frac{X-0.04}{0.04} = -0.0738 \rightarrow X = EUS_E = 0.037 = 3.7\%$

$N_E = 27{,}027 = [1000 / (12 – 2)] / 0.037 \times 10$

In this example, the increase in price and the consequent reduction in critical mass, was enough to compensate the reduction in demand following the increase in price, and therefore the number of residents needed to achieve critical mass decreased ($N > N_E$). However, the same cannot be said for all other occasions.

Other studies have been conducted in the car sharing industry regarding how changes in price may affect different market issues, other than achieving critical mass. Staff (2019) analysed how different pricing approaches may deal with fleet unbalance problems by increasing or reducing the price of picking up and returning vehicles in overflowing or empty stations. On a similar note, Jorge, Molnar, & de Almeida Correia (2015), believe that car sharing providers could be able to increase profits and efficiency by charging higher prices for trips that increase system imbalances and lowering price for trips that help equilibrate the network by moving vehicles form low demand locations to high demand locations. Zoepf & Keith (2016) studied the importance for car sharing users of distance and time needed to reach a vehicle over several attributes, including price. The researchers found that users are willing to walk approx. one mile more or shift their travel schedule by up to one hour in order to pay roughly $2/hour less for their vehicle. Similarly, Papu Carrone et al. (2020) derived the users' willingness-to-pay for several car sharing characteristics such as access time, reducing search time spent while looking for parking spots, and possibility of reserving vehicles in advance. Lagadic, Verloes, and Louvet (2019) established that, at the moment, all car sharing providers vehicles according to the "first come, first served" rule. This rule considers that the first person that books a vehicle will be the one who will use it. However, the researchers believe that the pricing schemes of car sharing will develop in the future to better meet a consumer's willingness-to-pay. Suggested developments includes dynamic pricing, in which prices adapt to the demand for vehicles according to their location, or "premium" pricing options, according to which customers that pay more will have a higher level of priority when booking a vehicle. Zhou and Li (2018) studied the electric vehicle market and found that government policies that reduced the cost of acquiring electric vehicles had a positive outcome and increased EV adoption. However, if the price for an electric vehicle is excessively high, the only long run outcome of the market is a no-adoption of the technology. Catalano et al. (2008) asked people in Palermo, about their preferred transport mode (including car sharing) as a function of time and cost. Paulley et al. (2006) studied the effects of changes in fares/prices, quality of service, income and car ownership on public transport demand. From their research they noticed that scholars tend to separate price elasticity between short run (one to two years), long run (twelve to fifteen years) and, on some occasions, even medium run (five to seven years). By analysing the public transport system in the United Kingdom, they discovered that on average short run elasticities are – 0.4, medium run elasticities stand at – 0.56, but most importantly, long run elasticities tend to be approximately -1 or slightly higher. This has profound consequences for public transports because, although the immediate effect of a price increase might be a temporary increase in revenue, the long-term effect is likely to be a decrease in revenue. The researchers also found that the price elasticity in the Shire counties (more rural parts of the United Kingdom) is much higher than the price elasticity in metropolitan areas in the United Kingdom. According to the researchers, this is the result of residents of large cities being more dependent on public transport than residents living in smaller cities, as rural residents tend to have higher car ownership levels. It may also be connected to the fact that rural residents tend to have to pay higher prices because journeys will on average last longer than those done by urban residents. Therefore, it is possible to conclude that "elasticity values tend to be higher in rural areas than in urban areas" (Paulley et al. 2006, p. 300).

### 2.7. Implications for Policy Makers

"The role of public intervention is important in order to generate movement and to provide harmony for social change; to prevent poverty and inequalities between regions, industries, or social groups" (Ramírez, 2009, p. 287). This includes creating equalities among urban and rural regions or social groups. According to Zhou and Li (2018), understanding the value of critical mass allows to improve the understanding of the diffusion path of the innovative technologies and to have the necessary knowledge needed to design effective policies to help promote the new technology.

Governments and policy makers are starting to recognise that they can, and should, play a more vital role in simplifying the process of providing services in rural areas by assisting companies through different methods (Lagadic, Verloes, & Louvet, 2019). In particular, they recognize the increasing importance they play in encouraging entrepreneurial activities and curbing market imperfections such as limits on access to financial support or local workforce skills, in rural areas (OECD, 2010). For instance, car sharing often requires public financing to reach its necessary critical mass in rural areas (Allen, Bonazzi, & Gee, 2017; Lagadic, Verloes, & Louvet, 2019). The current climate policy debate has also emphasised the role public interventions have on directing private finance towards green investments, such as renewable energy, alternative transportation modes, sustainable construction practices, etc. (Haščič et al., 2015). However, although governments recognise their importance in closing the urban-rural gap, many sectors still face inequalities when entering rural markets. In fact, inadequate political settings have been identified as one of the main barriers to the expansion of car sharing in many countries (Asthana et al., 2003), and most car sharing providers "do not benefit from the support of local authorities" (Lagadic, Verloes, & Louvet, 2019, p. 74).

It was demonstrated in chapter 2.4 and 2.5 that, because of the limited number of potential customers, service delivery in rural areas is more costly than in urban areas, making it harder to achieve critical mass. So, in order to present their services in rural areas and face these higher costs, car sharing providers can either offer their services at higher prices or reduce the quality of the service. Based on the results found through the formulas above [2, 10], it is possible to see how the price must change for the company to meet its breakeven point, according to different population sizes. By introducing $N$ as a fixed variable and leaving $P$ as the dependent variable, the equation is restructured as such:

$$P = (C_F / N) / EUS \times AES + C_V \qquad [12]$$

This demonstrates the price a car sharing provider would have to impose to be financially viable, given a certain population size in the area of interest. For instance, considering $C_F$ = 1,000, $N_E$ = 10,000, $C_V$ = 2, $EUS_E$ = 0.04, and $AES$ = 10, the price would have to be:

$$P = (1{,}000 / 10{,}000) / 0.04 \times 10 + 2 = 2.25$$

In other words, given the conditions above, the car sharing provider would have to offer its services at €2.25 to be financially viable. However, what happens if the population size changes? If the population size were to be 200,000 people instead of 10,000, the car sharing provider could offer the service at a different price:

P = (1,000 / 200,000) / 0.04 × 10 + 2 = 2.0125

Therefore, if all variables are kept constant, a person living in a rural area with 10,000 people would have to pay €0.2375 more than someone living in an urban area with 200,000 residents. Although a price increase can lead to a reduction in the divergence of rural and urban areas in terms of available services, rural residents still face higher costs to access these services or have to accept lower quality of services compared to urban residents. Thus, the divergence is still existing and can be reduced only through public intervention, meaning that urban and rural divergence remains a major challenge for governments and other institutions (OECD, 2010). This naturally begs the question: how can policy makers counteract this price increase and reduce the urban-rural divergence?

**Kommentiert [SM12]:** Should open questions be in italic or in between quotes?

The obvious and most direct solution would be that the government pays the price difference that the rural population encounters when accessing the service. The main factor influencing a person's choice in the mode of transport is generally its cost (Takahashi, 2017). Therefore, it is critical for policy makers to understand how different price levels may affect the demand of a certain transport mode (Yaman & Offiaeli, 2022) and act accordingly. If the government paid the €0.2375 extra that the car sharing provider is asking for offering its service in the rural area in question, this would allow the rural residents to access the same service, at the same price and at the same quality. However, this would cause large public expenses and would be difficult to manage. Therefore, other methods have to be considered.

For instance, policy makers could offer a fixed contribution to providers servicing areas that are seen as more expensive and riskier due to population size and density and would thus not be profitable to service (Lagadic, Verloes, & Louvet, 2019). This could be in the form of a direct subsidy or in other forms, such as tax reductions. Territories could be divided into areas according to how costly it is to offer service in that area (e.g., high-cost areas, medium cost areas, and low-cost areas). Providers could then receive a contribution based on the area in which they are offering their service. By increasing the number of categories, the territory is divided into, the policy will be more precise and effective. However, this also leads to a more complicated system. According to Zhou and Li (2018), who studied the adoption of electric vehicles in the United States, significant government subsidies were needed to push most electric vehicle manufacturers over the critical mass constraint.

**Kommentiert [SM13]:** Is this clear and does it make sense?

Another method, which would not cause such an important damage to the policy maker's budget, is to increase the price of urban areas to match the price of rural areas and use the generated income to further develop the car sharing system in rural locations. However, price elasticity of demand plays a critical role in this hypothetical situation because, if the price increase is too high, it could excessively damage the demand for car sharing in urban areas and would only worsen the overall adoption of car sharing services. Alternatively, to avoid decreasing the demand too much due to an excessive price increase, policy makers could implement instruments, such as taxes on car sharing providers, that would increase the price paid by urban car sharing users by half of the amount that rural consumer pay more compared to urban residents (e.g., €0.2375 / 2 = €0.11875). This sum could then be transferred to car sharing providers in rural locations to decrease the price for the final user by the same amount (€0.11875). In this way, both rural and urban users end up paying the same price. If the same provider is offering services in both areas, this can be achieved directly by establishing an average price that would allow the overall critical mass to be reached in both locations. The model developed by Saglia, Wagner and Dion (2022) would facilitate the creation of these two hypothetical situations and, therefore, allow for the existing price difference to be established in order to determine the level of tax, or other chosen method, that needs to be implemented in order to create an egalitarian situation for both rural and urban residents.

**Kommentiert [SM14]:** Is it clear how I worded it?

Another way of achieving the same result, would be to increase the *EUS* of rural areas. If *EUS* increases, then price can also decrease:

$$\downarrow P = (C_F / N) / \uparrow EUS \times AES + C_V \qquad [13]$$

To do so, policy makers may implement different techniques. For instance, car sharing is considered by many researchers to be strongly connected to public transport. These two services may function as either substitute or complementary goods. In the first case, by increasing the price of public transport the willingness to use car sharing would increase depending on the price elasticity of demand of public transport. However, this is not the goal policy makers wish to achieve, as they do not wish to move customers away from public transport and towards car sharing. Therefore, this is not a good option. Instead, the two services should complement each other, so that the high demand of one service will increase the demand also for the other (Lagadic, Verloes, & Louvet, 2019). Following this idea, Loose (2010, p. 3) believes that "it makes sense that car sharing providers should work in

collaboration with local or regional public transport organisations and develop package deals". Similarly, Best and Hasenheit (2018) deem that transport policies should develop a multi-modal transport system, in which the biking system and public transport should complement the role of car sharing. According to Lagadic, Verloes, & Louvet (2019), this represents a vital step towards MaaS (Mobility as a Service), which entails an extensive integration of information, booking and billing on a single platform, for a given territory. Examples of this complementarity among different services providers can be found in many cities, such as Brussels, Hannover, Madrid, Milan, Montpellier, Vienne, etc.
Through this role of complementarity, car sharing providers can benefit from the large customer base of the public transport system, while public transports can take advantage of this new mode to keep customers, improve customer loyalty, and profit from the innovative image that car sharing offers. "Academic research has shown that both partners profit in the end […] leading to a win-win situation" (Loose, 2010, p. 4). Additionally, this will increase the environmental and social benefits of car sharing (Best & Hasenheit, 2018).

Research found that that lack of awareness is often one of the main reasons why potential car sharing customers do not consider using the service. To increase demand of car sharing, policy makers could also support providers by allowing for free or cheap advertising and promotion in the area (Lagadic, Verloes, & Louvet, 2019). Increasing the product recognition may sway more people to at least try the service and could ultimately increase demand. To do so, local authorities could provide advertising spaces, like bus stops or train stations, position leaflets around the area, add an informative section on the city's website for car sharing, etc.

Strategies to improve car sharing demand, would appear to be particularly effective if directed towards the millennial generation. A study conducted across Australia and other car-reliant cultures such as the US, discovered that there appears to be a general decline in car ownership rates, especially among the millennial generation (Mulley, 2017). Therefore, car sharing would provide the flexibility of private cars to those who do not own one, but occasionally need it. Advertising should thus be directed mainly towards millennials.

Lagadic, Verloes, & Louvet (2019), also suggest another possibility to increase demand for car sharing. According to their view, by integrating the development of car sharing in the planning policies of rural (and urban) areas, this would allow car sharing to meet increasing numbers of potential consumers. For instance, by considering that carsharing performs better where parking spaces for private cars are limited, public authorities could consider during

new development planning to limiting the construction of new car parks. This would increase the expected penetration of car sharing on the market (Firnkorn & Muller, 2011). Moreover, car sharing providers could find partnership agreements with other companies to increase brand awareness. For instance, DriveNow developed a partnership with the German grocery retailer REWE, according to which each vehicle included a 5% discount to use in REWE stores. In exchange, REWE provided car sharing users with ten minutes of free parking after having stopped in one of the stores (Lagadic, Verloes, & Louvet, 2019). Another example can be found in Marseille, where the local car sharing provider, Totem Mobi, partnered with some retail stores in the area. The retailers, in exchange for the free visibility, allowed car sharing users to charge their electric vehicles at charging points installed by the retailers in front of their stores (Lagadic, Verloes, & Louvet, 2019).
Researchers also found that higher car ownership costs promote economizing behaviours, which in the case of mobility means a higher likelihood of people switching to public transport and car sharing (Giuliano & Dargay, 2006). Therefore, by implementing strategies that increase car ownership costs, policy makers may be able to boost the demand for car sharing services.

According to the OECD (2010), other strategies that may also be adopted to offer equal services to rural areas and overcome the issues found in chapter 2.4, include:

- *Aggregating demand*. "Too small a demand for locally provided services is one of the most common reasons for problems in rural service delivery" (p. 38). A solution could then be to find a way to aggregate demand and create a bigger customer base. For example, creating a single hub for car sharing in a bigger city, that then expands also to neighbouring town may help reduce total fixed costs. Research also shows that many car sharing providers are starting to integrate new mobility offers, such as car rentals, peer-to-peer offers, bike sharing, vehicle leasing, etc. (Lagadic, Verloes, & Louvet, 2019).
- *Consolidation, co-location or merging similar services*. Consolidation refers to the act of closing some service locations to increase the volume of people using the locations that remain open. However, this may increase the unit service costs because either the users or the service provider has to sustain greater travel costs. Co-location refers to aggregating together in one area multiple services, to build up demand and reduce the travel costs for incurred for each service. Merging services, means taking services that are in some sense

substitutes and combining them into a single entity. This allows to reduce fixed costs and take advantage of more economies of scale. The service provider starts sharing not only costs, but also risks, and creates a common and bigger customer base. An example of such practice comes from March 2018, when BMW (provider of DriveNow and ReachNow) and Daimler (owner of Car2Go) announced their intention of combining the mobility services they were offering (Lagadic, Verloes, & Louvet, 2019).

- It is possible also to adopt more than one of these approaches at the same time to achieve an even higher increases in demand.

- *Create a new service to achieve better outcomes*. This refers to supplying a new service that has the same outcome of the old one but is more adapted for the rural situation. Instead of rescaling the same exact service that is offered in the urban areas, tailoring it for the rural needs may be a better strategy.

- *Improve quality and marketing*. According to the OCED, often the cause of too little demand in rural areas has to do with the lack of attention to marketing. By investing more in marketing, service providers may be able to build a bigger customer base.

Finally, although subliminally mentioned also in some points above, another feasible way of creating the conditions to accommodate equal prices in rural and urban areas, would be to reduce either the fixed costs or the variable costs of the rural provider.

$$\downarrow P = (\downarrow C_F / N) / EUS \times AES + \downarrow C_V \qquad [14]$$

Although a change in variable costs, would have a greater effect on changing the price than an equal percentage change of fixed costs, reducing the latter is noticeably easier than reducing variable costs. In the model developed by Saglia, Wagner and Dion (2022), it is possible to find thirteen voices of fixed cost, and only three of variable cost. Additionally, the variable costs that were found in order to operate a car sharing service, were costs that could hardly be removed or reduced. Costs for petrol or electricity to charge electric vehicles are obviously essential for a car sharing business, and their cost does not depend on the provider of the service, but rather on the conditions of the market. Another voice of variable costs includes online payment fees. Because car sharing works predominantly online, it would not be possible to remove these costs, nor can their value. The electronic payment market is governed by very few strong competitors, who decide on what fee to charge, and this is generally non-negotiable. Car maintenance costs connected to car trips, the third variable costs included in the mode, have some range of being adapted, but still very few things can be done to reduce these already small costs. On the other hand, fixed costs, such as rent, asset depreciation, equipment, employees, etc., are values that can be more easily cut by switching to cheaper alternatives. So, how can policy makers create a situation in which it would be less costly to start a business in a rural area?

According to Liu & Tyagi (2017), the act of outsourcing production, services, and other economic activities can convert fixed costs into variable costs. This conversion, according to the researchers, can help businesses by consenting them to withstand higher prices. “Intuitively, when firms produce the products or service in-house, their fixed costs rationally become sunk costs when they decide their prices and hence price competition is intense. On the other hand, when they outsource and then compete on prices, then the conversion of fixed costs into variable costs implies that they compete with reduced fixed costs and higher variable costs, allowing them to sustain higher prices” (p. 253). However, the researchers themselves, show that outsourcing will most likely end up increasing the costs per unit and therefore doesn’t help find a solution to reduce prices in rural areas.

Policy makers could share information about patterns and trends of public transports (Lagadic, Verloes, & Louvet, 2019). Having more information on how demand for transportation services change in time and space could allow car sharing providers to position their vehicles more strategically, thus allowing them to save money by reducing the number of vehicles needed and also save money and time on market research.

Another big area of fixed costs for businesses usually comes from buildings and land. Public authorities may provide car sharing providers with free parking spaces and office spaces at a discounted price, to help them reduce fixed costs. This could be done, mainly for the initial stages during which providers is still building the necessary customer base. For example, the city council of Copenhagen provided stationary car sharing providers with cheap access to reserved parking space at a cost of only €30 per car for the entire year (Lagadic, Verloes, & Louvet, 2019). In Madrid, electric vehicles, plug-in hybrids, an electric shared vehicles can park everywhere for free and without a time limit (Lagadic, Verloes, & Louvet, 2019).

Other equipment can also denote a major area of fixed costs for service provider, and especially car sharing providers. One example could be the cost of installing charging points around the city for electric vehicles. The example chosen for this case, is represented by the city of Amsterdam. In last decade, the municipality has installed an extensive public network of electric vehicle charging points and reached agreements with the electric companies to charge only certain amounts at the vehicle charging points. This not only promoted the use and adoption of electric vehicles in the city, but it also led Car2Go to launch its first 100% electric car sharing vehicles service in Amsterdam. The main reason for this decision was the lower fixed costs the company would have to endure, because of the already existing network of charging points (Lagadic, Verloes, & Louvet, 2019).

However, the biggest cost of all, is usually employees. One solution to this problem could resolve to a community-based solution. Often, communities are willing to help entities, if they see their presence as an important aspect for the community. Volunteer fire departments or community owned shops are some examples of this (OECD, 2010).

When reflecting on all possibilities to resolve the matter of critical mass, it becomes possible also to consider that public authorities may also enter the carsharing market directly and become providers, without third-party intermediaries (Lagadic, Verloes, & Louvet, 2019). This would not actually solve the problem of critical mass, however, being a public actor, it is possible for them to operate also at a deficit and use public budgets to finance the activity. This can come in the form of public companies or joint ventures.
Service providers could also act directly on the profit, by creating alternative revenue streams. For instance, car sharing providers could sign agreements where, in exchange of a payment, they provide advertising for other companies by putting stickers on the sides of cars or by leaving leaflets available for the users in the car (Lagadic, Verloes, & Louvet, 2019).

Overall, Zhou and Li (2018), showed through their research the importance of critical mass constraints on designing policies to stimulate technology adoption. From their results, it appeared that spatially differentiated policies are more effective for overcoming critical mass constraints, than standardised policies, and lead to a higher adoption rate of the technology. It is import, however, also to consider possible effect of over-subsidization because, when the total demand for a service is too low to justify the presence of other providers, current providers face little pressure to compete or to deliver their services in a cost-effective manner (OECD, 2010).

## 3. Literature Review

Over 160 articles have been analysed during the creation of this research. All of which have been cited in the text or in the footnotes following to the APA 7th edition standards. All publications and research were consulted between August 2022 and November 2022. These were included withing the research on the basis that they were relevant to conduct this research, the source was considered trustworthy and reliable, the research was considered sufficiently updated and according to the number of citations of the academic literature. Research would be secluded if not fitting with the research if they were considered too outdated or if their source was not trustworthy.

In this chapter a brief literature review will be provided regarding the most important publications that have been used to complete this research. The literature review consisted of three primary areas of research: the car sharing situation and its environmental and social benefits, the urban-rural divergence, and the assessment of critical mass and break-even analysis. The review will be organised in tables by describing title of the research, author/s, and year of publication. Each research will be ordered alphabetically according to the title. Also, a brief description and the main reasons why the research were selected will be presented in the notes at the bottom of each table.

All the articles mentioned in the literature review were selected from the main online academic publishers such as: Elsevier, Harvard University Press, Sage, Sciendo, Springer, Routledge, Taylor & Francis, and Wiley and Sons. From these publishers, several research journals in the field of health, society, science, politics, sustainability, transportation, etc. were consulted. Also, articles from governmental and intergovernmental organisations were taken into consideration during the writing of this research. Examples of these organisations may be: EU Commission, EU Parliament, OECD, United Nations, and the World Bank. Finally, publications by trusted organisations whose scope is to retrieve and analyse data were used studied. Examples of these organisations may be: Bundesverband CarSharing, Deloitte, Our World In Data, Papers.ssrn.com, Statista, The International Council on Clean Transportation, UC Berkeley: Transportation Sustainability Research Center. Articles were selected by searching keywords either directly in the academic publisher's online portals, or through search engines such as Google Scholar. There were three principal areas of study. To research them, the following search criteria were entered: (1) "car sharing" OR "car-sharing" OR "carsharing" OR "shared vehicles" AND "critical mass" OR "break-even point" OR "financial viability" OR "financial stability"; (2) transportation OR mobility OR transport OR “road vehicles” OR cars AND emissions OR GHG OR “greenhouse gas” OR pollution OR “health issues” OR “health problems”; (3) “urban-rural divergence” OR “urban and rural divergence” OR “urban-rural gap” OR “urban and rural gap” OR “urban vs rural” OR “urban and rural divide” AND “critical mass”.

**Kommentiert [SM15]:** Move to Appendix?

**Table 3**

*Car Sharing Services Literature Review*

| Title | Authors | Year |
|---|---|---|
| Car Sharing: A New Approach to Urban Transportation Problems. | Katzev, R. | 2003 |
| Car Sharing Relieves the Environment and Traffic. | Bundesverband CarSharing | 2016 |
| Shared Mobility Report 2022. | Statista | 2022 |
| The Environmental Benefits of Carsharing: The Case Study of Palermo. | Migliore, M., D’Orso, G., & Caminiti, D. | 2020 |
| The State of European Car-Sharing. | Loose, W. | 2010 |

*Note. This first literature review includes the most important publications that were used during the composure of chapter 2.1, 2.2, and 2.3, which aimed at gaining a better understanding of the car sharing market and the environmental, social, and economic benefits that this system could provide.*

The research conducted by Katzev (2003), although a bit outdated, was used as it provided a good base for the history of car sharing, why it was developed and how the early adapters viewed the system when it came into play back in 1987.

The Bundesverband, represents the umbrella organization controlling all the car sharing in Germany, and for this reason it has managed to gather a lot of data regarding German car sharing providers and users. It provided a good base to understand, not only concrete data on the car sharing situation in the biggest car sharing market in Europe in terms of members: Germany, but also, its effect on society and the environment. Although they do not have official publications, their website held all the necessary information there is to know, which is regularly updated, and proof checked by the organization.

Statista (2022) proved to have the most updated and complete information on the expected future trends in the global car sharing scenario, not to mention also a very complete set of data regarding the transport sector in Germany and in the world. It also provided straightforward ways to compare different geographical locations.

Migliore, M., D'Orso, G., & Caminiti, D. (2020) analysed with a lot of detail and accuracy the positive environmental effects that car sharing has had in the city of Palermo, and how extending this service to most other areas could help the planet.

Finally, Loose (2010) was charged by the European Commission to conduct a very deep and complete analysis of the European car sharing situation. Project momo (More Options for energy efficient MObility through Car Sharing) had the aim of discovering if car sharing could represent an effective solution to limit one of the most prominent issues that governments are facing today: global warming. Therefore, the researcher studied what effect existing car sharing systems were having on the environment and how these trends could evolve in the future.

**Table 4**

*Urban-Rural Divergence Literature Review*

| Title | Authors | Year |
|---|---|---|
| Acceptance of Electric Car Sharing in Rural Areas. | Silberer, J., Mrso, M., Bäumer, T., & Müller, P. | 2022 |
| Establishing Car Sharing Services in Rural Areas: A Simulation-based Fleet Operations Analysis. | Illgen S. & Höck M. | 2018 |
| Rural and Urban Areas: Comparing Lives Using Rural/Urban Classifications. | Pateman, T. | 2011 |
| Strategies to Improve Rural Service Delivery. | OECD | 2010 |

*Note. The second literature review covers the analysis conducted on the divergence between urban and rural areas, as one of the aims of this research is to solidify the knowledge about this gap. This divergence represents a crucial issue for most governments and other policy makers. The review reflects the research conducted in chapter 2.4.*

Silberer et al. (2022), studied the inequalities among urban and rural populations and the authors main contribution to this research was discovering that although rural residents are open and willing to use car sharing services, they are faced with some limitations. In particular they brought concrete and precise data on where car sharing services were offered in Germany. This allowed the author to see that almost all car sharing services were offered in urban areas with more than 100.000 residents. Therefore, it proved the connection between the urban-rural gap and population size or customer base.

The research conducted by Pateman was considered for its input in distinguishing what differentiated the rural from the urban population and was vital in understanding the differences in pollution production, especially connected to transport.

However, probably the most important publication used when talking about the urban and rural divergence, was the one published by the OECD in 2010. The reduction of the urban-rural gap is so clear and so important for this intergovernmental organization, that a specific research body and a specific policy review has been created to improve rural service delivery. This publication was fundamental in first of all giving confirmation about there being a gap between the two areas, by mentioning multiple times that rural areas are faced with scarcer and weaker services compared to their counterparts. It was then essential to understanding the root causes behind the divergence, by uniting other researcher's thoughts and creating a standard set of issues that rural locations face. Other than that, it analysed the growing importance of the service sector in employment and economy, even for rural regions, it studied the rural population, giving data about demographics, consumption patterns, etc. and finally provided readers with some issues for rural areas, but also practical solutions to the existing policies.

Finally, although Illgen and Höck do not speak strictly of the divergence between urban and rural areas, they do however mention that the rural side of car sharing has been excluded from most recent publications that address car sharing, which in some way indirectly represents one of the gaps covered by this research. The authors do also analyse the limitations of why some services, and in particular car sharing, are not offered in rural areas and by doing so they introduce the idea of critical mass and how it is needed for a company to be financially viable. In addition, the research also states the potential of create a nationwide car sharing organisation and how this would exponentially increase the social and environmental benefits of the system.

**Table 5**

*Critical Mass Literature Review*

| Title | Authors | Year |
|---|---|---|
| Critical Mass and Network Size with Application to the US FAX Market. | Economides, N., & Himmelberg, C. P. | 1995 |
| Critical Mass Is Not Enough. A Monte Carlo Study of Sharing Economy Business Models. | Saglia, M., Wagner, R., & Dion, P. | 2022 |
| Failure to Launch: Critical Mass in Platform Businesses | Evans, D. S. & Schmalensee, R. | 2010 |
| Perceived Critical Mass and the Adoption of a Communication Technology | Craig Van Slyke, Virginia Ilie, Hao Lou, & Thomas Stafford | 2007 |

*Note. The third literature review assesses the publications that have been used to analyse how to calculate an entities critical mass and how this can and should be expanded to the number of residents living in an area, which have been reported in chapter 2.5. Critical mass has been presented as the main goal to reach for a business to become successful, but also as the reason a rural and urban gap remains; It is harder to achieve critical mass in rural areas. These publications were selected to be the most important in clarifying what critical mass is and how to calculate it.*

The publication issued by Economides and Himmelberg (1995), although outdated, was chosen as it represents one of the first researches in which the term critical mass was allocated to a context similar to the one referred to in this research. In the researchers' words, critical mass is "the smallest network that can be supported in equilibrium" (Economides & Himmelberg, 1995). The researchers work represents the basis to this research and most other research in which critical mass represents the number of customers that an enterprise or product has to reach to be financially viable. To which follows the fundamental idea that no equilibrium market could exist for a good or service, unless the customer base is greater than the critical mass point. The researchers also introduced the idea that consumers' expectations of low perceived critical mass may lead these expectations to be fulfilled. The surge in demand (+150%) for fax machines that occurred between 1986 and 1987 served as a proof that of their theory. The demand growth was not actually led much following shifts in consumer demand, but rather it was driven by the positive feedback of users and the expected future increases in the size of the customer base.

Saglia, Wagner and Dion (2022), published the most influential study that was used for this research. They were among the few to point out the importance, not only of critical mass, but also of the number of residents needed to achieve such critical mass (*N*). They demonstrated that, if such requirements cannot be reached, the business or product will fail, and the technology will not be adopted. This same idea is used at the core of this research. The researchers also provided the necessary formulations to calculate such numbers [2, 3], which have been used and reported in section 2.5 and 2.6. Although the researchers developed their model for a different purpose; to prove the urban and rural divergence, that same model is used in this research to answer the two research questions: (1) how do price changes affect the critical mass, and (2) how do price changes affect the number of residents to achieve critical mass. The model has been adapted to suit rural conditions and for a stationary car sharing model and has been manipulated to leave price as an unknow variable. By inserting distinct levels of price, and leaving all else unchanged, this has allowed to see how changes in price affect critical mass and *N*.

The research by Evans and Schmalensee (2010) was used first of all to describe critical mass. It was also considered as an introduction to section 2.6., because according to their view if an entity couldn't achieve its critical mass requirements, it would have to increase prices to try and cover costs or will fail. This idea fits with the hypothesis of this this research, according to which an increase of price, given a fixed willingness to use the service, allows to lower the critical mass requirement. Finally, their development of the networking affect, was used to provide further strength to the concept of critical mass.

The most important publication considered when it comes to critical mass is the one by Saglia, Wagner and Dion (2022). The researcher's idea and formulation that expressed that not only is critical mass important, but that also the required number of residents living in the area is a fundamental concept to increase the understanding of the urban-rural divergence was at the base of this research. Their formula: ($S_P$ / $EUS \times AES$) was the principal concept that guided the research and the methodological part, which is presented with further detail in chapter four. By manipulating the model developed by the researchers and leaving the price as an unknown and interchangeable variable, it allows to see what price levels would allow to reduce the critical mass (*N*) for operating a car sharing business and with it also the number of required residents living in the area.

**Table 6**

*Effect of Price on Critical Mass Literature Review*

| Title | Authors | Year |
|---|---|---|
| Breakeven Analysis: The Definitive Guide to Cost-Volume-Profit Analysis. | Cafferky, M. E., & Wentworth, J. | 2014 |
| Incorporating Stochastic Demand into Breakeven Analysis: A Practical Guide. | Yunker, J. A. | 2006 |
| The Demand for Public Transport: The Effects of Fares, Quality of Service, Income and Car Ownership. | Paulley, N., Balcombe, R., Mackett, R., Titheridge, H., Preston, J., Wardman, M., Shires, J., & White, P. | 2006 |
| Understanding Car Sharing Preferences and Mode Substitution Patterns: A Stated Preference Experiment. | Papu Carrone, A., Hoening, V. M., Jensen, A. F., Mabit, S. E., & Rich, J. | 2020 |

*Note. This fourth literature review contains the publications that were used while analysing how changes in price can affect the critical mass and the number of residents needed to achieve this critical mass (chapter 2.6). A focal point of this research fell upon the price elasticity of demand for car sharing which can be found in the third and fourth articles listed in Table 6, and in additional publications not mentioned in the review.*

Cafferky and Wentworth (2014) provided an important theoretical background on which to build the formulations and the models developed in chapters 2.5 and 2.6, by stating that, as prices increase, critical mass reduces and vice versa. The researchers proved that by increasing the denominator, the dependent variable (critical mass) would decrease and that, although this is true, managers have to also consider that an increase in price will negatively affect customer behaviour. The researchers believed that the break-even analysis remains a fundamental and useful concept in the business world, but it may need to be adjusted and enhanced to reduce limitations, make results more accurate and extend it to more business situations, while still remaining simple to use. This proves the use of this research and how its results may be valuable to scholars and policy makers.

Although Yunker (2006) had a different view regarding how to integrate price elasticity if demand within the break-even function, the researcher also believed that as price increases the break-even point reduces and vice versa. This article was also useful to deduct some important theoretical foundations regarding price elasticity and break-even point.

The publication by Paulley et al. (2006), is an important aggregation of previous research on the topic of public transport demand and how several variables, such as fare price, quality of service, income level and car ownership, all affect demand. This publication, was mostly useful for collecting the information it provided regarding the price elasticities of demand that has been recorded in the last few decades, how this has changed throughout time and how this elasticity is affected by the time frame considered (short run and long run), the mode of transport in question (e.g., bus, rail, metro, etc.), the difference a change in price can have depending on the area type considered (rural vs urban), and how the price elasticity changes according to the time of day studied (high-peak vs low-peak moments).

Papu Carrone et al. (2020), tried to discover how car sharing affects peoples' travel behaviour. To do so, the researchers studied how individuals value various attributes of car sharing services and analysed the substitution patterns between car sharing and traditional transport modes (private cars, public transport and bike). By doing so, they estimated the user's willingness-to-pay for vehicle reservation, parking availability and convenient access to car sharing vehicles and formulated the cross-elasticity of car sharing with the other modes of transport described above. To the knowledge of the author, this research is one of the very few that has managed to estimate the price elasticity of demand of car sharing. Therefore, this elasticity was chosen to represent a key aspect in the calculation of *N* when changes in price occur. Additionally, this research was useful to prove that free-floating car sharing is a strong competitor of public transport, which was a first indication that public transport price elasticity of demand may be used as a proxy for car sharing price elasticity.

**Table 7**

*Implications for Policy Makers Literature Review*

| Title | Authors | Year |
|---|---|---|
| Can Carsharing Services Be Profitable? A Critical Review of Established and Developing Business Models. | Lagadic, M., Verloes, A., & Louvet, N. | 2019 |
| Strategies to Improve Rural Service Delivery. | OECD | 2010 |

*Note. This Table includes the most important publications used during the creation of Chapter 2.7, which discusses what implication the urban and rural divergence and critical mass may create for policy makers. This chapter also includes possible ways through which policy makers can help reduce the divergence, by helping service providers achieve their critical mass.*

The article by Lagadic, Verloes, & Louvet, (2019) published in the transport policy journal, was critical to the policy makers chapter of this research. Although the main topic of the article is not strictly represented by the role of policy makers, it also provides a comprehensive list of suggestions on how policy makers and other authorities can address the issue of urban-rural divergence. Although it does not explicitly say whether or not car sharing service should receive public subsidies, it does provide ways through which public authorities and other entities may help car sharing providers reach their critical mass, and thus cover all their costs. The publication describes in detail how actors operate in the car sharing industry and presents a complete overview of the innovations that have emerged in the market. The authors also present many practical examples of how some public authorities have managed to help car sharing providers reach their critical mass and suggest other strategies that could be implemented in the future to further reduce the problem. This article proved to be particularly useful in order to understand all the dynamics and developments of the car sharing industry and how the interactions between different parts occur.

Although the report published in 2010 by the OECD was already mentioned in one of the previous literature reviews, it was chosen to include it also in this section because of its importance in creating a framework meant to inform policy makers and local authorities about the divide between urban and rural areas, and guide them through the process of trying to eliminate, or at least reduce, this divide. The report is titled "Strategies to Improve Rural Service Delivery", exactly because it recognises the lack of service availability in rural areas following the several difficulties it identifies, that make service delivery harder in rural areas. The first chapter of this report about the role of service, what the divergence is, and why it exists. However, the second chapter discusses how public intervention can help the service delivery issue. Questions such as "What services should be provided?", "Who should provide the service?", "What mechanism should be employed for service delivery?" and "How are the service delivery mechanisms to be funded?" are answered in this chapter. The third and concluding chapter of this publication regards more the designing part of the service delivery. In this research, the report from the OECD was fundamental to establish the essential role that only public interventions can have in reducing the urban-rural divergence. It recognized the role public authorities have in encouraging entrepreneurial activities and curbing rural market imperfections and identified several strategies that can be used to overcome the critical mass issue that troubles most rural service providers.

## 4. Methodology

Due to the nature of my research, the methodological part represents the core work of the research and therefor will need several weeks, if not months, to be completed. For this reason, it is still being written and therefore will not be presented in the exposé. However, give an idea about what I am planning to do, the following is the structure of how the methodology is going to be developed:

1. *Phase 1. Explaining the model.*
   In this part it will be critical to explain in as simple terms as possible how the model works, how the numbers will be processed and why certain values were chosen (where they come from, why were those picked, etc.)

2. *Phase 2: collecting the data.*
   Given the formula: $C_F / (P - C_V) / EUS \times AUE = N$, the variables $C_F$, $C_V$, *EUS, AES* will have to be calculated following a lot of research on previous studies, case studies, market analysis and possibly by contacting existing car sharing providers already operating in the field. These variables must be representative of a rural area. This has already been done for the research with Professor Wagner and Dion, however these were representative for urban (Berlin) areas, therefore they will now have to be adapted for rural areas.

3. *Phase 3: estimating the price.*
   *P* will have to be estimated on the bases of existing prices, costs, etc. However, the reason that level of price was chosen will have to be motivated carefully.

4. *Phase 4: running the model (doing a Monte Carlo simulation).*
   All variables, including p, will have to be inserted into the model, to estimate the N of a rural condition with a price *P*. The results will be run 10.000 times to reduce statistical errors.

5. *Phase 5: Saving results and manipulating the model.*
   Once the results have been obtained and saved, a first result can be given. Would a company operating in the rural area in question be viable, given the current price level

and costs? Following this the formula will be manipulated to have *P* as the dependent variable.

6. *Phase 6: Testing the different prices*
   Having all other variables known, $C_F$, $C_V$, *EUS*, *AES*, and *N*, by testing various levels of price, it will be possible to see how the necessary critical mass and number of residents living in the area needed to cover costs (*N*), adjust according to the price. Each result must be saved for the next step.

7. *Phase 7: Analysing the results*
   What were the results? What do they mean? What could this suggest?

By considering the fixed costs, variable costs, expected use of service and available equivalent services of a rural area in which a car sharing provider may be interested to operate, different price levels can be applied. However, the model developed by Saglia, Wagner and Dion (2022), allows for some uncertainty. Because costs change in time, operators may choose different qualities or simply accept different offers, in the researchers model each variable has a range rather than a single value, and then a random extraction selects a value to insert within the formula. Again, selecting only one value out of all the possible solutions may lead to remarkably high statistical errors. To avoid this problem, the model runs the formula 10 thousand times, each time randomly selecting each value from within the variables range.

This research uses the model developed by Saglia, Wagner, & Dion (2022) in their paper "…." and manipulates prices within the model to try and discover what price increases in the car sharing services would allow such service to be offered in small/medium populated areas. Such result may be useful, not only to private entities interested in operating in such industries, but also to policy makers and public entities, as it may be extended to other on-site services and demonstrate what interventions are needed to reduce and potentially eliminate the urban-rural gap. Such results appear to be particularly important nowadays, when public interventions to promote and implement sustainable activities over large portions of the population are critically important and a growing concern among many people.

## 5. Expected Contributions

Is price able to reduce critical mass and the number of residents needed to achieve such critical mass? Is it possible to provide equal services to both urban and rural areas? How may policy makers play a key role in reducing the urban-rural gap? These are some of the questions that have tried to be answered in this research. Overall, the goal is also to create more interest in both scholars, policy makers, and other parties towards the rural area.

### 5.1. Scholarly Contributions

Like in society (Loose, 2010), even in the academic world, there has been a gap between urban and rural studies. Most research concentrate on the urban side while often, rural areas have been ignored (Illgen & Höck, 2018). Although it is true that urbanization is at its highest peak, reaching a global average of 56%, with roughly 4.4 million people now living in cities (World Bank, 2020), rural areas still play an important role in the world's economy, society and environment. This role will become increasingly important as the population grows, spaces become limited and resources scarce. Therefore, there is a growing need to study more about how rural location can help sustaining population growth, help fight global warming, and increase employment levels.

The contribution of this paper is fourfold. First, it provides an overview on the current situation of car sharing around the world, reviewing most of the recent studies in the field and providing useful information regarding the trends in the car sharing market. Second, it analyses the issues of the current transportation system and provides the potential benefits that car sharing may have on the environment, society and economy. Third, it reviews the current divergence between rural and urban areas and encourages researchers to study more about this issue and, in particular, how different pricing strategies and policies may help alleviate the problem. Finally, this study will help scholars gain further understanding of the model developed by Saglia, Wagner and Dion (2022) and extend the research conducted by the researchers.

Although the role of break-even analysis is nothing new, the systematic literature review that was conducted in chapter 2 and chapter 3 found that very limited research has been done to determine how price changes affect service break-even points (critical mass), and how this can be used to further solidify the knowledge regarding the urban-rural divergence. In fact, the whole concept of break-even has evolved for many years around the idea of product manufacturing and has left services out of the equation. Moreover, the existence and the effects of the urban-rural divergence have been studied mostly in Asia and North America, and little research has analysed the European context.

### 5.2. Implications for Business, Policy Makers, and Society

This article will be of great interest to service-based businesses that are thinking to expand to rural areas as well as to anyone who wants to know more about car sharing and the urban-rural divergence.

The research will allow companies to consider more rationally whether they should expand to rural areas, where they should expand, what likelihood of being successful they will have if they do, and what prices they should apply. Businesses could now have a model that will allow them to answer the question: “if I operate in this area, what probability do I have of covering my costs?” and “what price should I apply in order to achieve my goals?” No research, to the knowledge of the author, has allowed to do so up until now. Also, no research has previously been conducted analysing how higher prices may help decrease critical mass.

Policy makers will find further interest in the research as it aims to provide them with more concrete and transparent tools on how to allocate resources among different areas and, more specifically, on how to reduce the ongoing divergence between rural and urban areas.

This study’s findings will also benefit society as it will provide a clearer picture on why there is so much talk about car sharing and so much change in the transportation sector. It will also help understand more about why rural residents have limited services available, compared to people living in cities, or why they may be charged more. A detailed analysis of the existing research on transportation, its effects on society and the environment, and a focus on the car sharing world is therefore provided for anyone interested in these subjects.

## 6. Chapters Overview

Title page

Abstract

[In yellow are the part that I am still not 100% sure to add or not!]

# 7. Work Plan

| | TASK LIST | | | |
|---|---|---|---|---|
| | MY TASKS | DUE DATE | % COMPLETE | NOTES |
| 1 | **Theoretical framework 1: get feedback about current theoretical framework and fix mistakes** | tbd (based on when we get feedback) | 0% | Adjust theoretical framework based on feedback |
| 2 | **Theoretical framework 2: Decide whether to add the the basic central place theory to the urban-rural divergence chapter (2.4.)** | 30.10.2022 | 70% | I will ask a meeting with professor Zulauf shortly and ask what she thinks about me adding the theory. I already have the information needed if we agree to add it |
| 3 | **Theoretical framework 3: write a chapter regarding how changes in price may allow to reduce critical mass** | 04.11.2022 | 20% | I have not yet added it because I am worried that I have too much in my theoretical framing. However, I consider that this may help give a better idea of what I am doing so I think I will add it |
| 4 | **Theoretical framework 4: because one of my research aims is to provide ways policy makers can help make services available also to rural communities, maybe add also a chapter about this** | 09.11.2022 | 40% | I already have most of the information I would need to write this chapter (2.6.), however I still fear it may be too much stuff in the theoretical framing. |
| 5 | **Theoretical framework 5: ask an external person (not academic) to read the theoretical framework to see if it is clear, not too much of a boring read, if it's too long or if some parts need more detail** | send by 09.11.2022 | 0% | Adjust theoretical framework based on feedback (if valid) |
| 6 | **Literature review: adjust to feedback and based on the changes made from parts 3 and 4** | 11.11.2022 | 0% | See if professors agree with the articles I chose to put in the literature review and adjust based on feedback. Additional chapters may need to be added based on the results of part 3 and 4 of this work plan |
| 7 | **Methodology 1: description of the model** | 16.11.2022 | 40% | Hoping that the research with professor Wagner and Dion will be published before I submit my thesis, this step will be easy as all I need to do is recall the model provided in that research. However, I have some doubts that it will so, a deep explanation of how the model works will need to be given. Because the model has more than 100 calculations, this step will require some time. |
| 8 | **Methodology 2: gather data in order to estimate the variables** | 18.11.2022 | 20% | Ideally, I would manage to get someone from a real rural car sharing business to help me and give me real concrete data. In alternative an analysis of other case studies, financial statements, market analysis, etc. will be used. From my previous research I already have the voices or variable that I need to find so that is some work done |
| 9 | **Methodology 3: estimate the price** | 18.11.2022 | 80% | Estimate the price based on the price of competitors. This is just the initial base and then the price will be modified, so not too much detail has to go into deciding it. |
| 10 | **Methodology 4: run the model and save N** | 21.11.2022 | 90% | The model is already created and working, so once all the variables have been gathered and estimated, these will have to be added to the model. Once all are added then we can run the model and estimate N |
| 11 | **Methodology 5: first results** | 27.11.2022 | 0% | Some first results can be said. Given the N that we achieved, would the business be viable in that area with the price and costs level there are currently? |
| 12 | **Methodology 6: manipulate the model** | 30.11.2022 | 0% | Now that we have all the values, including N, the model can be put in function of p (which becomes the dependent variable). Several price levels can be inserted to see how N changes |
| 13 | **Methodology 7: analyse results** | 07.12.2022 | 0% | The results will have to be write and backed up by some assumptions and theoretical basis. Was the model capable of telling us how critical mass and N changed when prices change? How did they change? What does this mean? What can it mean for policy makers? And for society and the business world? |

| | | | | | |
|---|---|---|---|---|---|
| 14 | Expected contributions 1: adjust | 09.12.2022 | 70% | The expected contributions are already written. However, these should be adjusted based on the feedback received from the exposé and more detail can be given once the model has been run and conclusions have been formulated |
| 15 | Chapter overview 1: adjust | 09.12.2022 | 70% | The chapter overview has already been written, however it has to be update to any changes following all the parts above |
| 16 | Conclusions | 18.12.2022 | 0% | Write the conclusions based on the results obtained from the model and according to the suggested policies that can be done to help reduce the gap |
| 17 | Abstract 1: add conclusions | 20.12.2022 | 0% | The main part of the abstract has been written, however, the results have to be added |
| 18 | Title 1: check that title fits and is clear | 20.12.2022 | 90% | I think the title now it quite good and representative of the research. However, as researches change a lot while being written, it will have to be checked once all the thesis has been completed |
| 19 | Adjustments 1: yellow highlight | 30.12.2022 | 0% | Read through the whole thesis, make adjustments, and update or clear doubts on the things that are highlighted in yellow |
| 20 | Ask someone to read the thesis | 10.01.2023 | 0% | Once the everything has been checked ask someone to read over to check for mistakes and that everything is clear and understandable |
| 21 | Hand in | 13.01.2023 | 10% | Hand in final thesis! |

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